The Engineer

LONDON, FRIDAY, JULY 31, 1942.

PUBLIC NOTICES

UNIVERSITY COLLEGE OF SWANSEA

(A CONSTITUENT COLLEGE OF THE UNIVERSITY OF WALES.)

PRINCIPAL: C. A. EDWARDS, D.Sc., F.R.S.

APPLIED SCIENCE DEPARTMENTS

ENGINEERING.

Professor: FREDERIC BACON, M.A. (Cantab), M. Inst. C.E., M.I. Mech. E., M.I.E.E.
Lecturer in Electrical Engineering: R. G. HAACS, M.Sc. (Bristol), B.Sc. (Lond.), A.M.I.E.E.
Lecturer in Civil Engineering: A. A. FORDHAM, Ph.D. (Lond.), A.M. Inst. C.E., M.I. Struct. E.
Lecturer: J. SELWYN CASWELL, M.Sc. (Wales), A.M.I. Mech. E., A.M. Inst. C.E.
Assistant Lecturer: W. E. J. FARVIS, B.Sc. (Bristol).

METALLURGY.

Professor: C. A. EDWARDS, D.Sc. (Manchester), F.R.S.
Assistant Professor: R. HIGGINS, Ph.D. (Glasgow).
Lecturer: R. GRIFFITHS, M.Sc. (Wales).
Assistant Lecturer: T. B. WILKINSON, Ph.D., B.Eng. (Liverpool).

The College Offers a number of exceptional advantages to students who aim at entering upon professional careers in Engineering or in Metallurgy. It is situated in the heart of an industrial area which includes a large number of works of very varied character, and presents an unrivalled variety of metallurgical practice. The manufacturers of the district, who contribute largely to the support of the College, give the staff and students of the Applied Science Departments easy access to the works, and the managers, engineers, and technical officials co-operate with the staff of the College in making visits to works of practical educational value to the students.

Courses of study are provided (1) for the B.Sc. Degree of the University of Wales in (a) Civil Engineering, (b) Mechanical Engineering, (c) Electrical Engineering, (d) Metallurgical Engineering, (e) Metallurgy; and (2) for Diplomas of the College in (a) Civil Engineering, (b) Mechanical Engineering, (c) Electrical Engineering, (d) Metallurgy.

Persons who are not desirous of studying for Degrees or Diplomas may attend selected College classes, provided they satisfy the authorities of the College that they are qualified to benefit by such classes.

ENTRANCE SCHOLARSHIPS will be offered for competition in April, 1943.

Particulars concerning admission to the College and of the Entrance Scholarships may be obtained from the undersigned.

EDWIN DREW,
Registrar.

Hingleton Park,
Swansea. 8557

UNIVERSITY OF LONDON

KING'S COLLEGE

FACULTY OF ENGINEERING.
CIVIL, MECHANICAL, ELECTRICAL and CHEMICAL ENGINEERING.

Complete Courses of Study, extending over three years, are arranged for the Engineering Degrees of the University of London and/or for the Diploma and Certificate of the College.

DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING.

Professor of Civil Engineering and Dean of the Faculty:—
C. H. LOBBAN, D.Sc., M. Inst. C.E.
Professor of Mechanical Engineering:—
S. J. DAVIES, D.Sc., Ph.D., Wh.Ex., M.I. Mech. E.

DEPARTMENT OF ELECTRICAL ENGINEERING.

Siemens Professor of Electrical Engineering:—
J. K. CATTERSON-SMITH, M.Eng., M.I.E.E.

CHEMICAL ENGINEERING.
(Discontinued during the War.)

For full information and prospectus apply to THE SECRETARY, KING'S COLLEGE LONDON, at The University, BRISTOL, 8. 8598

RUNWELL HOSPITAL

NEAR WICKFORD, ESSEX

Fitter Required for Power-house; must be thoroughly experienced in the Running and Maintenance of High-speed Steam and Diesel Electric Generating Plant. Wage £5 per week of 48 hours.
Applications, with full particulars and copies only of testimonials, to be sent to the PHYSICIAN SUPERINTENDENT as soon as possible. 8655

The Engineer

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NOTICE

CORRESPONDENCE *re* Accounts and Remittances should be sent in future to:

28, ESSEX STREET, STRAND, LONDON, W.C.2, and NOT to Bath.

This change has been caused by enemy action, and co-operation is earnestly asked for.

PUBLIC NOTICES

SHROPSHIRE EDUCATION COMMITTEE

WALKER TECHNICAL COLLEGE, OAKENGATES

Applications are Invited for the POST of ENGINEERING LECTURER. Candidates should preferably have qualifications in Electrical Engineering. Full-time post, including the Junior Technical School and Evening Classes.
Salary in accordance with the Burnham Technical Scale.
Applications, with copies of three testimonials, should be sent to the undersigned not later than August 15th, 1942.

H. MARTIN WILSON,
Secretary for Education.

Education Office,
County Buildings,
Shrewsbury. 8667

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED, an Experienced SUPERINTENDENT MAINTENANCE ENGINEER for Hydraulically Operated Shell Forging Plant. State age, experience, and when free to commence duties.—Address, 8665, The Engineer Office. 8665 A

DRAWING - OFFICE TRADE.—ASSISTANT SALES MANAGER REQUIRED by well-known Company. Must have thorough knowledge of all branches of the trade. The position offers good prospects to applicants of outstanding ability.—Address, P4273, The Engineer Office. P4273 A

LONDON FIRM of GENERAL ENGINEERS and IRONFOUNDERS REQUIRES MANAGER for Factory in Midlands employing 300 hands.—Address, giving summary of previous experience, positions held and salary required, P4269, The Engineer Office. P4269 A

PUBLIC NOTICES

COUNTY BOROUGH OF READING

WATER DEPARTMENT

PANGBOURNE PUMPING STATION

PUMPING MACHINERY

The Corporation of Reading invite TENDERS from Manufacturers of Waterworks Pumping Machinery for the SUPPLY and ERECTION complete of a HEAVY OIL ENGINE-DRIVEN CENTRIFUGAL BORE-HOLE PUMPING PLANT, having a capacity of two million gallons per day, together with Auxiliary Plant and Accessories.
Copies of the specification and other relevant particulars may be obtained on application at the office of the Water Engineer and Manager, Town Hall, Reading, upon payment of a deposit of Three Guineas (cheques to be made payable to the Borough Accountant, Reading), which will be refunded upon the receipt of a bona-fide Tender and the return of all the documents.
Tenders must be delivered to the undersigned not later than Twelve Noon, Saturday, 29th August, 1942. No Tender will be considered unless enclosed in the plain envelope provided, sealed and endorsed "Tender for Pangbourne Pumping Plant," but not bearing any name or mark indicating the sender.
The Corporation do not bind themselves to accept the lowest or any Tender.

C. S. JOHNSON,
Town Clerk.

Town Hall,
Reading,
29th July, 1942. 8663

WEST MIDLANDS JOINT ELECTRICITY AUTHORITY

APPOINTMENT OF ASSISTANT CHEMIST

The above-named Authority invite APPLICATIONS for the POSITION of ASSISTANT CHEMIST (male or female), at a salary of £5 a week. The post will be designated under the Local Government Superannuation Act, 1937, and the successful candidate will have to pass a medical examination.
Candidates must have had a good general education and possess a sound knowledge of Chemistry, preferably to the standard of the B.Sc. Degree in Pure Science of the London University.
Applications, stating age, education, experience, and present occupation, accompanied by copies of three recent testimonials, and endorsed "Assistant Chemist," should reach the undersigned not later than 14th August, 1942.
Canvassing, either directly or indirectly, will disqualify.

H. F. CARPENTER,
Clerk and Manager.

Phœnix Buildings,
Dudley Road,
Wolverhampton.
24th July, 1942. 8664

TO ADVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the Advertisers. These notices (limited to one line) will be free of charge, and co-operation is asked for.

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CLASSIFIED ADVERTISEMENTS CLOSE FOR
PRESS-NOON WEDNESDAYS

The Engineer

Annual Subscription Rates

(including postal charges)

BRITISH ISLES	£3	5	0
CANADA	£2	18	6
ABROAD	£3	3	0

(except Canada)

ADVERTISEMENTS

The Charges for Classified Advertisements are 1/6 per line up to one inch—minimum charge, 6/-; those occupying one inch or more at the rate of 18/- per inch. Box numbers, 1/- extra, except in the case of advertisements under "Situations Wanted." Orders MUST be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Wednesday afternoon.

Letters relating to the Advertisement and the Publishing Departments of the Paper are to be addressed to the Publisher; all other letters are to be addressed to the Editor of THE ENGINEER.

Postal Address,
28, Essex Street, Strand, London, W.C.2.

Teleg. Address,
"Engineer Newspaper, Estrand, London."
Tel., Central 6565 (10 lines).

SITUATIONS OPEN

IMPORTANT

Advertisers in Situations Open Column should make themselves acquainted with the terms of

STATUTORY RULES & ORDERS
1941 No. 2069

RESTRICTION ON ENGAGEMENT ORDER

ADVERTISERS REQUIRE ASSISTANCE of FULL-TIME MACHINERY VALUER, preferably familiar with Iron and Steel Works and all classes of Machinery in Factories and Foundries. Liberal salary to competent men. Travelling and hotel expenses when away from home.—Please address, stating terms, 8666, The Engineer Office. 8666 A

NEWTON, CHAMBERS and CO., Ltd., WISH to APPOINT a GENERAL MANAGER for their Ironworks Branch, which includes Structural and General Engineering Departments, with machine shops, heavy and light castings foundries and blast-furnace, with large administrative and sales departments. Applicants must have had previous experience of large engineering works with full responsibility for manufacturing and technical sales management. Commercial experience is essential. Preference will be given to those between the ages of 35 and 50. —Applicants will be asked to complete a questionnaire, obtained on application to the SECRETARY of the COMPANY, Thorncliffe Works, near Sheffield. It is requested that no particulars of experience should be sent before the completion of the questionnaire. 8670 A

THE Post You Are Seeking May Not be Advertised in this Column, but do not lose the Opportunity of Bringing your Requirements before all those who would be interested and could employ you. An Advertisement in the "Situations Wanted" Column would be seen by all Leading Engineering Concerns for the cost of Four Lines, 6s.; 1s. 6d. for each Additional Line. There is no better way of covering so large a field for such a small charge.

DRAUGHTSMAN, About 21, for Maintenance, Clinker Processing Plant; £286 p.a. Air Ministry work. Resident now in Metropolis and free from Essential Works Order. Interviews Saturday afternoons.—Write only, HIBBERTS, Ltd., Thames Works, Vicarage Crescent, Battersea, S.W.11. P4244 A

SITUATIONS WANTED

ADVERTISER WISHES to CONTACT FIRMS requiring a SENIOR EXECUTIVE for the purpose of reorganising, co-ordinating and controlling Buying, Progress, Sub-contract, Stock and Stores Departments. Age 35 (not liable for military service). Extensive experience and an able controller of large staff. Interested only in a position of high responsibility with a salary of not less than £1500 p.a.—Address, P4279, The Engineer Office. P4279 B

EFFICIENT and VERSATILE EXECUTIVE, B.Sc. (Eng.), A.M.I. Mech. E., experienced administration, planning, production, development, DESIRES SHORTLY POST of Managerial status, starting £650 p.a., with scope. Work of national importance.—Address, P4259, The Engineer Office. P4259 B

ENGINEER (50), University Trained, Civil, mech., elec., of wide experience in design, construction, and operation of a variety of specialised plants and engineering works. Salary, £1000/1500. AVAILABLE NEAR FUTURE.—Address, P4236, The Engineer Office. P4236 B

ENGINEER (39), B.Sc., M.I.C.E., A.M.I. Chem. E., ten years' chief executive position, wide experience E.H.T. electrical installations, steam and diesel plant, constructional work, SEEKS RESPONSIBLE POSITION requiring initiative, organising capacity, and drive. London district preferred.—Address, P4281, The Engineer Office. P4281 B

SITUATIONS WANTED

A FULLY-TRAINED MECHANICAL and ELECTRICAL ENGINEER, Age 46, well introduced to Government Departments, railway companies, consulting engineers, &c., is PREPARED to REPRESENT FIRMS in the London and Home Counties area either whole or part-time. Office accommodation with telephone and clerical assistance can be provided in reception area. Car available. Replies treated in strict confidence.—Address, P4277, The Engineer Office. P4277 B

ENGINEER, A.M.I. Mech. E., Age 31, with management, design, buying, inspecting, and sound practical experience, having excellent record of ability, achievement and reliable service, REQUIRES CHANGE to good managerial post.—Address, P4278, The Engineer Office. P4278 B

ENGINEER, Age 39, Released Contract, URGENTLY REQUIRES EXECUTIVE POSITION, Twenty-five years' experience, home and abroad, in machine shop practice, plant layouts, erections, maintenance, marine, steam and diesel, hydraulic experience under N.C.F., last four years as plant engineer, assistant manager.—Address, P4265, The Engineer Office. P4265 B

ENGINEER (44), B.Sc., A.M.I. Mech. E., SEEKS progressive EXECUTIVE POSITION, preferably London area. Practical drawing-office, contract, sales, production and inspection experience.—Address, P4275, The Engineer Office. P4275 B

ENGINEER (39), A.M.I. Struct. E., Now supervising design and execution of large contracts, SEEKS progressive APPOINTMENT as Assistant Engineer or Chief Draughtsman in Mechanical and Structural Engineering; 20 years' engineering experience; last 10 years in responsible technical positions. Salary £600 minimum. South or West of England preferred. Must be establishment scheduled under Essential Works Order.—Address, P4272, The Engineer Office. P4272 B

EXPERIENCED EXECUTIVE ENGINEER, specialised in works management and maintenance in general engineering works, iron and steel foundries, can be released to take a MANAGERIAL POSITION offering scope and permanency. Age 44. Assoc. M. Inst. C.E. and Assoc. M.I.I.A.—Address, P4268, The Engineer Office. P4268 B

IF the Man You Are Seeking is Not Amongst those Advertising in this Column, a Small Announcement in the "Situations Open" Column will Quickly and Economically Produce the Right Selection of Applicants, at the same time Eliminating Waste of Effort, Waste of Time, and Waste of Opportunity. The charge is Four Lines or under, 6s.; each Additional Line, 1s. 6d. Box Numbers, 1s. extra, which includes despatch of all replies.

MACHINE SHOP FOREMAN (50), Life Experience, 9 years' aero-engine production, well up with auto. and capstans, used to female labour.—Address, P4276, The Engineer Office. P4276 B

MECH. ENGINEER, First-class Practical knowledge, DESIRES POST as Works or Production Manager. Salary required £1250-£1500.—Address, P4270, The Engineer Office. P4270 B

MODERN ENGINEER (42), with 26 Years' practical experience of wide and varied nature in elect. and mechanical engineering and building maintenance, DESIRES CHANGE for a position in S.W. of England. Last 12 years as administrative factory engineer. Present salary £800 p.a.—Address, P4280, The Engineer Office. P4280 B

WORKS MANAGER (38), A.M.I.C.E., Public school and university, fully experienced production engineer and works administrator. Able to take full control. Proved ability to reorganise or expand production. Thorough knowledge of Factory Acts, A.R.P., &c., as applied in a large factory. Able to obtain release for more responsible work. Salary required about £1250.—Address, P4233, The Engineer Office. P4233 B

WORKS MANAGER, Reorganisation, Systems, methods expert. London or near. Immediate results.—Address, P4267, The Engineer Office. P4267 B

PARTNERSHIPS

ADVERTISER WISHES to ENTER into PARTNERSHIP with Engineering Firm engaged on work of national importance. The proposition is most suitable to a firm wishing to increase its output, as a factory is available, together with a staff of 50 capable of being trained in assembly, &c.; normal works capacity, 150.—Address, P4235, The Engineer Office. P4235 C

GENTLEMAN, with £700 Available, WANTED to Assist in old-established and profitable Commercial Financial Consultant's Business, specialising in procuring capital for engineering and allied industries. Full or part-time occupation at own office or residence, London or Provinces. Substantial income should be made.—Address, P4274, The Engineer Office. P4274 C

MECH. ENGINEERING WORKSHOP, approx. 15 machines, with or without Government contract, WANTED; also interested in Partnership.—Address, P4271, The Engineer Office. P4271 C

EDUCATIONAL

AUTHORITATIVE CORRESPONDENCE TRAINING

25 FIRST PLACES

and HUNDREDS OF PASSES in the A.M. Inst. C.E., A.M.I. Mech. E., A.M.I. E.E., A.F.R.Ae.S., A.M.I. Chem. E., C. & G., etc., Examinations have been gained by T.I.G.B. Students.

Especially in view of Air Raid and Working Conditions, study at home with the T.I.G.B. in order to achieve the best progress and results. Write to-day for "The Engineer's Guide to Success"—FREE—containing the world's choice of Engineering Courses—over 200—covering all branches and recognised qualifications. Mention branch, post of qualifications that interests you. The T.I.G.B. guarantees training until successful

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN
76, TEMPLE BAR HOUSE, LONDON, E.C.4.

MACHINERY, &c., WANTED

WANTED, CYLINDERS and VALVES for Water Softeners, 300, 400, 500 capacity.—State price to WHEELER and SONS, The Softener Men, 1, High Street, Scunthorpe. P4266 F

ALL CLASSES OF MACHINE TOOLS WANTED. Cash paid.—NORMAN POTTS, 105, Alcester Road South, Birmingham, 14. 8649 F

We are licensed by the Machine Tool Control for the purchase of all classes of Machine Tools, and we offer good prices for surplus Machinery in any quantities, large or small.

F. J. EDWARDS, LTD.
359, EUSTON ROAD, LONDON, N.W.1
Telephone No.: EUSton 4681
Telegrams: "Bescotools, Norwest, London."

ALFRED HERBERT, Ltd., Coventry, PAY BEST PRICES for SECOND-HAND MACHINE TOOLS in good condition by first-class makers.
Write, wire, or 'phone, and our representative will call.
'Phone: 88781 (12 lines), Coventry. Telegrams: "Lathe, Coventry." 1002 F

URGENTLY REQUIRED, Cochran or Cross-tube BOILER, giving an evap. capacity of 6000 lb. per hour, or would consider two smaller Boilers, 100 lb. pressure.—Address, 8643, The Engineer Office. 8643 F

For continuation of Small Advertisements see page 54.

THE standardised card advertisements below are inserted in place of the firms' large advertisements which have been omitted due to the paper shortage.

BRITISH ROPEWAY ENGINEERING CO. LTD.
P.O. BOX, PETERSFIELD, HANTS
See our displayed advertisement
JULY 17

BROOM & WADE LTD.
HIGH WYCOMBE, BUCKS
See our displayed advertisement
JULY 24

HEENAN & FROUDE LTD.
WORCESTER, ENGLAND
See our displayed advertisement
JULY 17

FRANK PEARN AND COMPANY LIMITED
MANCHESTER, 12
See our displayed advertisement
JULY 17

ROBERT STEPHENSON AND HAWTHORNS LTD.
DARLINGTON and NEWCASTLE-ON-TYNE
London Office: 20, GROSVENOR GARDENS, S.W.1
LOCOMOTIVES for all Gauges and Services
Telegrams: Telephones:
Locomotive Newcastle-on-Tyne. 22431.
Rocket Darlington. 2700.
Fossicker, Sowest, London. Sloane 8111.
Codes: Bentleys, The New Standard.

COMPANY MEETING

PETER BROTHERHOOD LIMITED

EXPANSION OF BUSINESS

MR. A. M. NEAL'S SPEE

The THIRTY-FIFTH ORDINARY GEN MEETING of Peter Brotherhood Limited held on July 28th, at Winchester Hous Broad Street, London, E.C.

Mr. A. M. NEAL, J.P., A.C.G.I., A.M (Chairman of the Company), presided.

The SECRETARY (Mr. Joseph Gerrard) read the notice convening the meeting an report of the Auditors,

The CHAIRMAN said: Ladies and gent As the Directors' Report and Statemen Accounts have already been circulated, m take them as read, please? ("Agreed.") is not necessary to go so much into detail other years, but I should like, if I may, t a few remarks on the Balance Sheet and Ac which have been circulated.

BALANCE SHEET ITEMS

If you will kindly refer to the Balance on the Assets side, the first two items co favourably with last year. In view of the e sion of business and the large payments w necessarily made for material for contracts in hand, I think you will agree that the figure of £132,123 is satisfactory, although figure will, of course, be materially reduced we have made our contribution to taxatio the undivided portion of the profits made.

The other items on the Assets side d appear to call for special comment, with exception perhaps of the last item—Air Precautions Suspense Account at £2 Towards this you are to-day, as you will from the Directors' Report, asked to agree aside a further sum of £5000, which, with amounts to be recovered from the Govern and with future allocations, will ultim liquidate this item from the Balance Sheet.

On the Liabilities side, the increase amounts owing to sundry creditors is £3 This item is naturally of a varying na depending on the dates of delivery of and ment for supplies, but provision for tax at £100,000, as last year, is a further remind the demands which must be met.

Turning to the Profit and Loss Account the bottom of the page the net profit for year, before providing for Income Tax and Profits Tax, is £160,386, against a figure last of £161,969, but the Income Tax and Profits Tax reduce the amount of net profit year available for distribution and for purposes to £60,387, against £61,969 last ye

Whereas the turnover for the year has more than maintained, it will be seen that trading profit is slightly lower than in the of last year. This is due partly to an inc in cost of production consequent upon abno conditions, but chiefly to the diminis margin of profit allowed to us in our cont prices.

DISTRIBUTION OF PROFITS

The question of a final dividend has carefully considered by your Board, who unanimously decided that in view of the amount payable for taxation, the shareho are entitled to as large a dividend out of profits remaining as is reasonably poss Accordingly, after setting aside the sum of already referred to for air raid precautions a sum of £5000 for special repairs and rene made necessary by the present condition working, and after allocating the sum of £ for general reserve, we have unanimously dec to recommend the payment of a final dividen 12 per cent. on the Ordinary shares, mak with the 8 per cent. interim dividend alr paid, a total dividend for the year of 20 cent. on the Ordinary shares.

It is usual here to make some remarks a the future. Under existing circumstances it is not possible, for we take our instruc from time to time from those who alone are in position to know in which direction we can most useful.

TRIBUTE TO STAFF

I should like, however, to take this opp tunity of acknowledging, on behalf of t Board, the loyal service rendered by the st particularly the works staff, and by the wh people during the year, and of thanking eve one for the way in which the standard of t company's service has been maintained.

I now have pleasure in moving the adopt of the Accounts and the appropriation of pr in accordance with the recommendation of t Directors.

Mr. W. T. FREESTONE, M.I. Mech. E Deputy Chairman, seconded the resolution, w it was carried unanimously.

The dividends, as recommended, were approv the retiring directors, Mr. J. H. Kemp-We M.B.E., and Engineer Rear-Admiral F. Haddy, M.V.O., were re-elected; the Auditor Messrs. Whinney, Smith and Whinney, were appointed, and the proceedings then terminate

A Seven-Day Journal

The Committee of Public Accounts

THE Committee of Public Accounts has given special consideration to important questions arising on contracts for essential war supplies, and its first report has been published by the Stationery Office. The minutes and proceedings of the Committee are now in process of preparation, and will, it is expected, be published in due course. The questions put before the Committee were whether the prices agreed in the cases under consideration were reasonable, and whether the decisions of the Government Departments were influenced by lack of information due to contractors' unwillingness to allow full investigation of their costs or profits or by fears that in the absence of settlements satisfactory to the contractors, production or delivery might be unfavourably affected. The Committee has considered the cases referred to it as a matter of urgency, and has taken full evidence from representatives of the contracting firms concerned, as well as from the Government Departments. As a result of its inquiry the Committee is glad to state that it is satisfied generally that whatever disputes may have occurred in the course of negotiations, there was, in fact, in no case any restriction of production or failure to produce the articles required. In its report the Committee states that there were some points on which both the Departments and certain contractors appeared to be open to criticism, and in the report some of these particular cases are examined under the headings of the several Departments concerned. The report concludes with a note by the Treasury on the subject of excess profits tax and contract policy, which lays down the policy that the contracting department should aim at securing fair and reasonable terms for stores to or services performed for the State, paying no regard to questions of taxation and acting in this respect as any prudent and reasonable purchaser would act.

The Dehydration of Foods

AT a meeting of the Nutrition Society, which took place in London on Saturday last, which was followed by a scientific discussion on food drying, Sir Edward Appleton, Secretary of the Department of Scientific and Industrial Research, said that in peacetime we normally imported something of the order of 3,000,000 tons of water as part of our foodstuffs. At the beginning of the war a group of scientific workers in the Department of Scientific and Industrial Research had therefore attempted to anticipate a likely need by making an intensive study of food drying, and it was this work, done in advance of requirements, that was proving so valuable to-day. In addition to the reduction in volume, the drying of food eliminated the need for refrigeration during transport. The drying of foodstuffs was not, of course, new. Where recent progress had been made by the Department's workers at Cambridge and Torry was in connection with the predrying treatment of the foodstuffs, the conditions during drying, and in methods of packing. At the discussion on Saturday, papers were read on the drying of meat, eggs, fish, and vegetables.

American Production Progress

ACCORDING to *The Times* correspondent in Washington, the recent report to the American nation of Mr. Donald Nelson, the Chief of the War Production Board, states that production is going well, but that the biggest part of the job is still ahead, and there must be no diminution of the feeling of urgency for more, faster, and better production. Some raw materials might, he said, become scarce in the future. Taking 100 for the last month that America was at peace (November), Mr. Nelson showed that while the production figure for July, 1940, was only 23, it reached 199 in March, 1942, and in June last was 286. It is stated that production in the first half of 1942 was 50 per cent. more than that for the whole of 1941. These figures cover aircraft, ships, tanks, guns, ammunition and campaign equipment. With regard to aircraft, Mr. Nelson says that the last published figure was 1914 for September last, and that by May, 1942, that figure had risen to nearly 4000. Anti-aircraft guns had presented a big problem, but production was increasing fast, and must increase more in order to overcome the earlier lag. Figures for anti-tank guns and artillery are 2000 a month, and machine guns 55,000 a month, while in May last 1500 tanks were built. With regard to ships, 228 were delivered in the first six months of this year, compared with 103 for the whole of 1941. The outputs of steel, aluminium, magnesium, and copper are increasing, but the war industries need more of these metals, and scrap metal collecting is advocated. The rate of war expenditure quoted by Mr. Nelson for June was £4,000,000 a day, or 36 per cent. of the national income of America, compared with only 2 per cent. in 1939.

Payment by Results in the Building and Civil Engineering Industries

THE Ministry of Works announces that bonuses are now being paid to building and civil engineering operatives whose output is higher than "basic" for all the main building and civil engineering operations on over 2000 Government sites which are scheduled under the Essential Work Order. Since the publication of the memorandum "Payment by Results" by the Stationery Office in March this year, a number of additional trade schedules have been approved by the Ministry of Works and Planning, fixing bonuses for the following operations:—Slating and tiling; hutting; hollow tile floor and roof construction; track laying; prefabricated formwork; hollow precast concrete floor and roof construction; carpentry and joinery (additional items), staining, varnishing. It has been laid down in Schedule 22 that the bonus of boys working in gangs is to be computed in the same ratio as the boys' rates to the craftsmen's rate. The Ministry of Works and Planning has also recently issued "Payment by Results" Notes No. 2, a leaflet which answers many of the questions asked by contractors who are responsible for applying the system. Copies of the additional trade schedules and the new No. 2 Note may be obtained on request from the Ministry of Works and Planning (A.S. 64), Lambeth Bridge House, London, S.E.1.

Canada's Metal Output

IT is announced that a number of the leading mining experts in Canada have been brought together to serve on a Committee under the chairmanship of Mr. R. A. Bryce, President of the Canadian Institute of Mining and Metallurgy, to investigate the possibilities of increasing Canada's output of zinc, copper, and lead. Meanwhile, the Canadian Department of Mines is redoubling its effort to open up new sources for these and other vital war minerals. Twenty-eight parties of prospectors and scientists are engaged in examining existing deposits with a view to seeing if they can be exploited further, reopening old workings which closed when the pre-war market became unprofitable, and putting down trial shafts in areas not hitherto opened up. Among the minerals sought for are deposits of Scheelite, a tungsten ore, manganese ores, mica, fluorspar, and cobalt ores. Mineral researches of a similar kind have been organised by the Canadian Department of Mines for many years, but the present search is the largest yet arranged.

Producer Gas for Transport Vehicles

SPEAKING in the House of Lords last week, Lord Leathers said that the Government's plan to equip 10,000 vehicles with producer gas plant is being pressed forward. He announced that two types of improved apparatus—a water filter system and a dry filter system—had been developed, and it was proposed to order 5000 of each. Most of the large manufacturers of goods vehicles were co-operating and would arrange for the fitting of the plants. Of the water filter type, Lord Leathers said, 2500 had already been ordered and would be produced eventually at the rate of 400 a week. The final design of the dry filter type had just been completed, and he hoped to place an order for 5000 within a few days. The limitation in the production of anthracite fuel made it impossible at present to undertake a bigger programme than 10,000. Mr. J. W. Noel-Jorden, the Chairman of the Mobile Producer Gas Association, recently put forward an additional plan for vehicle conversion, which, he said, consisted mainly of standardising all those parts of producer gas plants common to all types so as to allow for their mass production. Starting immediately, lorries could be converted at the rate of 200 per week for the first three months, and thereafter at the rate of 400 a week, giving 10,000 or more vehicles running on producer gas in less than nine months.

A Proposed Joint Technical Board

IN our last week's issue we dealt briefly with the deputation from the Parliamentary and Scientific Committee which recently waited upon Mr. R. A. Butler, Chairman of the Scientific Advisory Committee, and President of the Board of Education, to put forward a plan for a Joint Technical Board. Writing in one of last Sunday's papers, Lord Samuel, who introduced the deputation, has amplified the information we gave. He said that the concrete proposal submitted was that there should be established a small Board or Office, consisting of five or six industrialists and scientists, all of whom, unlike the members of the present Advisory Committee, should devote the whole of their time to this vitally important work. They would maintain, of course, the closest contact with the Chiefs of Staff organisation and the scientific departments of the three Service Ministries, as well as with the Ministry of Production. They would no doubt associate with themselves as advisers a large number of men who were in personal touch with the various sections of the scientific and technical world. They should be given a status of authority and leadership in that province of the general organisation with which they were concerned. President Roosevelt had, he said, provided a very similar system, and something here was very necessary. To create here a Joint Technical Board, to staff it with the right men, to free them from all other work, and, above all, to put it under the presidency of the right Chairman—that, Lord Samuel said, seemed to be the most urgent need of the moment.

A Panama–Mexico Highway

A PLAN to assist transport in the Central American countries has been under consideration for some time. It is now announced by the State Department in Washington that arrangements have been concluded with the Central American countries concerned for the immediate building of a gravel highway between the southern frontier of Mexico and Panama. It is understood that the United States Government will meet the cost of the construction of this new road. It is pointed out by the State Department that the new road will not only be of strategic importance, but it will assist transportation in the countries of Central America, which hitherto have been obliged to depend almost solely on shipping in order to meet their transport needs. Already considerable work has been carried out on the construction of the Alaskan highway, and when this and the new Panama and Mexico highway are completed there will be a through roadway between the north-western tip of America and the Panama Canal. The road through Central America has already been surveyed, and its construction will soon be begun, the length of the road being about 625 miles.

CONSTRUCTION OF THE CHEROKEE DAM

(For description see opposite page)

CONSTRUCTION VILLAGE AND CONCRETE MIXING PLANT
VIEW OF DAM FROM DOWNSTREAM
ERECTION OF CONSTRUCTION TRESTLE

The Cherokee Dam

No. II

(*Continued from page 77, July 24th*)

BOTH aggregates and bulk cement reached the dam site over the access railway, built by the T.V.A., and the aggregates were placed in storage piles nearby the concrete mixing plant, while the cement, which arrived in box cars, was unloaded into hoppers, from which it was moved by bucket elevators and transferred either directly to the mixing plant or to an adjacent silo of 600-barrel capacity, to be withdrawn as needed at the mixing plant. The three-storey mixer building, in which the flow of the raw materials was by gravity, had its mixers on the second floor, and the mixers delivered their charges into 4 cubic yard buckets standing on railway flat cars immediately beneath. Each train consisted of one flat car, with three buckets, and a diesel locomotive. Three trains shuttled continuously between the concrete mixing plant and the revolving cranes on the construction trestle, and the cranes picked up the buckets of concrete, one by one, and dumped the concrete into the forms. The forms for the downstream face of the spillway section had absorptive liners to produce a dense concrete surface where intense wear is expected. Also, similar liners were used on the forms for the power-house superstructure in order to impart a better architectural finish. The liners or lining have been of fibre board and made of a light-weight and highly absorbent material. The surface finish is dense and smooth. The concrete body of the Cherokee dam has required a total of approximately the equivalent of 750,000 barrels of cement, in addition to which a considerable volume of cement has been required in the grouting process of the foundation treatment. The total of the aggregates used—sand and crushed rock—has been 1,500,000 tons, of which 450,000 tons have been sand. Something like 700,000 cubic yards of concrete have been placed in the central structural features of the dam. The concrete used on the project has been composed of type "B" moderate heat cement and manufactured aggregate, that is, principally dolomite; and the compressive strength of twenty-eight-day cylinders for the required classes of concrete varied from about 3600 lb. to 5800 lb. per square inch in sample tests, while the compressive strength of a series of concrete cores drilled from the dam has ranged from 4000 lb. to 9000 lb. per square inch.

The concrete has been divided into two main classes, *i.e.*, mass, interior or unexposed, and face concrete, which is exposed. Mass concrete has had a water-cement ratio of 0·75 by weight and a cement content of from 0·8 to one barrel per cubic yard. The face or exposed concrete has had a water-cement ratio of 0·55 by weight and a cement content of from 1·15 to 1·75 barrels per cubic yard. The green-cut method has been generally used for the treatment of horizontal construction joints. Liquid membrane curing compound, consisting of a resin base in a toluene vehicle with a fugitive red dye added, was used for concrete curing of all surfaces except horizontal joints and finished floors. Tests indicated that membrane curing gave better than average field results, but was admittedly not so effective as continuous water curing.

Starting with December, 1940, every effort was made to place the concrete in the Cherokee dam at a rapid rate, and there was a period of three months during which more than 100,000 cubic yards of concrete was placed per month. In April of 1941 a maximum performance was recorded in placing more than 132,000 cubic yards. The greatest production of concrete for a 7½-hour shift was 1974 cubic yards, and that figure closely approached the theoretical maximum of 272 cubic yards per hour for the concrete plant, based on 4·4 cubic yard batches with a mixing cycle of 2 min. 55 sec. The massive concrete gravity section of the dam has a length of 1830ft., with an earth fill section that adjoins it on the north and has a length of 2150ft., and an earth fill section on the south that has a length of 2880ft.

The two main embankments are formed principally of earth and rock and consist of an impervious clay core that is supported on the upstream and the downstream slopes by heavy rock fill. The rock was obtained from a large dolomite quarry favourably situated downstream from the dam on the north bank of the river, and the clay was hauled from borrow pits adjacent to the dam site. These materials were transported by a large fleet of end dump lorries that had a maximum capacity of 12 cubic yards each. In handling the clay fill for the embankments two methods were employed.

Because some of the clay lay close to the surface in the borrow pits, the material often carried more moisture than the specified optimum, and particular care had to be exercised to control the moisture. It was accomplished by alternating the loading in a pit from one area to another, and damp clay was thus exposed to induce drying, so that it would be in a proper state for compaction at the fill site. Compaction of the clay fill was done by rolling the material, which was spread in 8in. loose layers, with sand-ballasted sheepsfoot rollers that exerted a pressure of approximately 300 lb. per square inch. Disc harrows were normally attached to and trailed behind the rollers and served to rough the rolled surface, prevented the lamination of the fill and obliterated any tracks formed by the hauling equipment. In this way, each layer of earth was firmly bonded to the preceding one. The rollers, which were pulled by caterpillar tractors, were required to make a minimum of ten passes over each layer of fill. Where the rollers could not be used, crews of labourers, equipped with hand pneumatic tampers, compacted the fill around the edges and in the cut-off trench. The impervious clay core of an embankment is fortified on the upstream slope, first by a blanket of small rock, which, in turn, is covered by a much thicker blanket of heavy quarry-run rock. The downstream slope of each embankment is protected by a blanket of quarry-run rock, with a bed of small rock at the downstream toe of the core, where there is provision for drainage. The rock on the slopes was placed in 25ft. lifts, and then power equipment was used to trim the slopes to final alignment. The basic shale surface under the upstream rock fill, before starting to build the embankments, was protected from alternate wetting and drying, and to seal open joints along the foundation bedding planes, by laying on the rock a fill of rock with dirt and fines to a depth of 10ft. to 15ft. to form a fairly impervious blanket immediately over the foundation shale. The rock was sluiced with water during this operation to consolidate the material and so reduce to a minimum any final settlement of the completed fill. The saddle dams were constructed entirely of rolled clay with the exception of the upstream slope of saddle dam No. 1, which was covered with heavy rock. The Cherokee dam required the excavating of 751,000 cubic yards of earth and the excavating of 245,000 cubic yards of rock. In the earth embankments there have been placed 1,657,000 cubic yards of rolled clay fill, 1,432,000 cubic yards of quarry-run rock fill, 250,000 cubic yards of crushed rock fill, and 40,000 cubic yards of sand filter. At the peak of operations on the embankments, 25,000 cubic yards of earth and rock were placed in the course of a working day.

The drainage area tributary to the pond above the dam is 3428 square miles, and the average normal flow of the river for thirty-five years is estimated at 4650 cubic feet per second. The maximum recorded flow, seventy-five years ago, was 150,000 cubic feet per second, and the minimum natural flow in later years was 500 cubic feet per second. To meet these extremes, the spillway of the dam, which has a length of 412ft., is provided with nine openings, in each of which there is a radial gate, 40ft. long and 32ft. high. The gates will be operated by a 60-ton travelling hoist, with electric drive, that will run on a track on top of a service bridge. The crest of the dam is 20ft. wide. The discharge capacity of the overflow spillway, with the surface of the pond at maximum high-water level—El. 1075—will be 254,000 cubic feet per second. To regulate the flow of the river downstream from the dam other than by water going to the power house through the penstocks, there are eight sluices that pierce the massive concrete near the bottom of the spillway section. Each sluice has a cross-section of 5ft. 8in. by 10ft., and is equipped with a hydraulically operated slide gate. The total discharge capacity of the eight sluices, when the pond is at its high-water level, will be 34,000 cubic feet per second.

The power station, which is adjacent to the spillway section at its north end, is of the so-called semi-outdoor type of construction, and has been designed to accommodate four generating units, but will be equipped at the start with but three units. Water will be delivered to the hydraulic turbines through steel-lined penstocks, one for each unit, that are 19ft. in diameter. The admission of water to each penstock will be controlled by a structural steel head gate, 15ft. 2in. by 26ft., equipped with roller trains, and each head gate is to be operated by a fixed hoist. The trash rack structures at the gates are four reinforced concrete semi-circular towers. Each generator unit is rated at 33,333 kVA at 0·9 power factor, and at 94·7 r.p.m., normal speed, will generate three-phase, 60-cycle current at 13,800 volts. They are of General Electric Company manufacture. The turbines, built by S. Morgan Smith Company, are of Francis vertical shaft, counter-clockwise rotation type, and each has a rated capacity at 94·7 r.p.m. of 41,500 H.P. at a 100ft. head. The diameter of the runner (discharge) is 14ft. 3in. and the vertical distance from the centre line of the distributor to draught tube floor is 37ft. The turbines are spaced, centre to centre of the units, 61ft. apart. At the start the plant will therefore provide a block of much-needed energy totalling 90,000 kW, and later, when the fourth unit is installed, the available maximum output will be 120,000 kW. For some months work has been going for-

ward with dispatch in installing the power-house units, and they will undoubtedly be ready to be put in operation when water impounded by the dam has reached a satisfactory stage. It was with this end in view that the dam was closed on December 1st, 1941, so as to be ready to garner the run-off of the watershed during the last winter and the spring of this year and so fill the reservoir and make the new plant available for service during the first half of 1942.

As the Cherokee dam stands it blocks the Holston River and effectually arrests the passing of any river traffic. However, the plans of the undertaking include the installing of a lock or locks to facilitate navigation up and downstream. The total cost of the Cherokee project is placed at 34,500,000 dollars. Credit for what has been done in rearing the Cherokee dam should be given to T. B. Parker, chief engineer of the Tennessee Valley Authority; A. L. Pauls, chief construction engineer; and R. T. Colburn, construction plant engineer; and at the dam, Lee G. Warren, project manager; G. K. Leonard and T. F. Taylor, construction engineers; and G. E. Murphey, superintendent.

The building of the Cherokee dam, through its control ultimately of the Tennessee River, helps to furnish necessary impulse water for two hydro-electric units, totalling 50,400 kW at Wilson dam and one 36,000-kW unit at the Pickwick landing dam, the three units supplementing the previously existing installations. These additions were covered by the first emergency programme, which will increase the T.V.A. power output by 356,400 kW. About a year later the second emergency programme of the T.V.A. was authorised and now under way, which will supplement the existing power plants by 212,400 kW, making the total capacity of the T.V.A. installations 2,000,400 kW; and this is to be further augmented by 595,300 kW mainly by adding other generating units to plants already built or authorised. The latest and largest of the new projects is the Douglas dam on the French Broad River, which will cost 30,000,000 dollars. This project is now under way and will eventually develop 100,000 kW. It will be ready to generate energy in 1943 just when the demand for power will probably be most pressing.

Model Quality Control Charts

By H. RISSIK, A.M.I.E.E., M. Amer. I.E.E., A.I.I.A., F.R. Stat. S.

No. II

(*Continued from page 65, July 24th*)

TIPPETT'S RANDOM SAMPLING NUMBERS

THE idea and practice of sampling is as old as trade. Before a purchaser commits himself to buying supplies in bulk, he must be satisfied that the consignments he is going to receive from the manufacturer are of the desired quality. So he inspects one or more samples of the manufacturer's product before placing his order. As a further protection he will nowadays insist on a so-called sampling clause in the purchasing specification, calling for the testing of one or more samples drawn at random from each consignment as received from the manufacturer. The acceptance or rejection of the consignment will then depend on the results of this agreed inspection test.

One of the outstanding advantages of quality control in manufacture is that acceptance of a product may safely be based on the manufacturer's evidence of controlled quality, as provided by the control chart, rather than upon the results of the purchaser's own inspection. In particular, if continuous control chart records are by agreement made available by the manufacturer to the purchaser, the latter will then need to test only occasional samples by way of checking the quality control records furnished by the manufacturer. This inspection policy has already been accepted in principle by the A.I.D.,[10] and signs are not lacking of a similar change in outlook on the part of the inspection departments of other production Ministries besides the M.A.P.

Now the quality control method is basically a sampling inspection method applied to production processes. In considering any model of such a process we are thus interested in being able to draw repeated samples of the product during the actual course of manufacture. At the same time, if, as we have assumed for the purpose of our experimental model, the process is one yielding a quality-controlled product, then we may legitimately consider random samples taken from the product after manufacture. Our immediate practical problem therefore is how to obtain random samples from an experimental model of a quality-controlled product such as that already discussed in connection with Table I (*ante*).

The classic method of random sampling used by statisticians in verifying their theoretical results is to draw balls or tickets from a bag or urn. Practical experiment has demonstrated, however, that it is impossible to mix the balls or shuffle the tickets adequately between each draw. In fact, to quote the late Professor Karl Pearson, founder of the British statistical school, "it is as difficult to get artificially true random samples as it is to sample effectively a cargo of coal or of barley." To get over the difficulty of random sampling for experimental purposes, L. H. C. Tippett some time ago introduced a single random system of numbers to replace the whole system of tickets, balls, and playing cards previously used in large-scale random sampling tests. Tippett's "Random Sampling Numbers" comprise 40,000 digits taken at random from census reports and combined by fours to give 10,000 numbers from 0000 to 9999. They are arranged in a table with 80 blocks of 20 digits to each page, each block containing five four-figure numbers. A small portion of the first page of this table is reproduced in Table II.

TABLE II.—*Tippett's Random Sampling Numbers*

1 2 3 4	5 6 7 8	.....	29 30 31 32
2 9 5 2	6 6 4 1	.....	5 6 2 4
4 1 6 7	9 5 2 4	.....	2 6 9 3
2 7 3 0	7 4 8 3	.....	7 6 9 1
0 5 6 0	5 2 4 6	.....	8 7 7 6
2 7 5 4	9 1 4 3	.....	6 4 4 6
5 8 7 0	2 8 5 9	.....	2 7 6 3
9 2 6 3	2 4 6 6	.....	2 6 8 3
2 0 0 2	7 8 4 0	.....	7 1 0 8
9 5 6 8	2 8 3 5	.....	6 5 1 5
8 2 4 3	1 5 7 9	.....	7 1 5 1
. . . .	. . . .	.....	. . . .
. . . .	. . . .	.....	. . . .
. . . .	. . . .	.....	. . . .
. . . .	. . . .	.....	. . . .
. . . .	. . . .	.....	. . . .
. . . .	. . . .	.....	. . . .
4 7 5 2	4 5 1 9	.....	8 3 5 0
0 4 8 6	6 9 9 3	.....	6 8 0 4
4 9 4 2	3 0 0 4	.....	3 7 7 5
4 9 3 0	9 7 8 5	.....	8 0 9 2
2 3 4 9	1 5 9 4	.....	9 8 0 6

Reverting to our experimental model of a consignment of 10,000 bricks, having a mean transverse strength of 1000 lb. per square inch with a standard deviation of 200 lb. per square inch, how would we select a random sample of 100 bricks from the consignment, or, for that matter, a sample of 10? Tippett's table of random sampling numbers provides a simple and immediate answer to a problem which otherwise involves the actual numbering and shuffling of the 10,000 blank tickets which we only considered imaginatively in connection with Table I. Taking the first block of Tippett numbers in Table II, we have 2952 for the first random four-figure number. Referring this to column 3 of Table I, we see that it

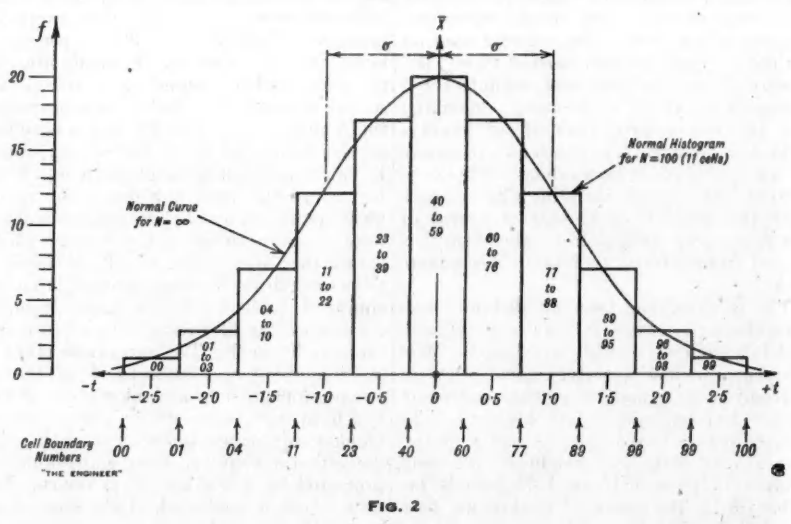


FIG. 2

[10] *Vide* the statement made by Mr. H. J. Lucas, Chief Inspector of the A.I.D., at the London Engineering Conference on Quality Control, April 15th, 1942 (reference 1).

[11] "Tracts for Computers: No. XV" (Cambridge University Press, 1927, price 3s. 9d. net).

falls into the eighth cell of the normal frequency distribution (Nos. 2266–4012 inclusive), for which the corresponding value of t is $-0{\cdot}5$. With $\bar{X}=1000$ and $\sigma=200$, equation (4) (*ante*) thus gives $x=\bar{X}+t\,\sigma=900$ lb. per square inch for the transverse strength of our first brick selected at random. Proceeding in this fashion throughout the first and ninth blocks of numbers in Table II, we build up a random selection of ten bricks as follows:—

Tippett number.	t.	Transverse strength, x.
2952	$-0{\cdot}5$	900
4167	$0{\cdot}0$	1000
2730	$-0{\cdot}5$	900
0560	$-1{\cdot}5$	700
2754	$-0{\cdot}5$	900
5870	$0{\cdot}0$	1000
9263	$+1{\cdot}5$	1300
2002	$-1{\cdot}0$	800
9568	$+1{\cdot}5$	1300
8243	$+1{\cdot}0$	1200

The mean strength for this particular random sample of ten is thus $\bar{x}=1000$ lb. per square inch, whilst the standard deviation is readily found to be $s=195$ lb. per square inch. By using the entire first eight columns of figures, instead of only the first ten rows in columns 1 to 4, twenty blocks of Tippett numbers can be used in the same way to obtain a random sample of 100 bricks from the consignment of 10,000.

The Model Quality Control Chart

Having considered the use of Tippett's random sampling numbers in selecting samples of any size from a normal frequency distribution of N items, having a mean $\bar{X}$ and standard deviation σ, let us now apply this same experimental method to the construction of control charts for sample averages $\bar{x}$ and sample ranges w,[12] in the case of a typical machine shop operation in production engineering work. By way of a specific example, we shall take a capstan operation producing a nominal piecepart dimension of, say, 0·125in., subject to a designed tolerance of $\pm 0{\cdot}003$in. The manufacturing tolerance for the production process in question is thus six-thousandths of an inch, and, for a quality-controlled process, this tolerance range will never be exceeded. As we are not primarily interested in the nominal dimension of 0·125in., but only in the deviations from this value, we may conveniently take $\bar{X}=0$ as a mean value, and measure x in, say, ten-thousandths of an inch positive or negative, according as to whether the piecepart actually produced has a dimension greater or less than 0·125in.

Assuming the process inspection of the pieceparts to be carried out by a clock gauge which can be read to the nearest five-tenths of 0·001in., and whose zero corresponds to 0·125in., a Normal frequency distribution of eleven cells and having a standard deviation $\sigma=0{\cdot}001$in. will satisfactorily represent the variations in piecepart dimension under conditions of controlled product quality.[13] Using the general method of Table I, but taking for simplicity the two-figure numbers from 00 to 99, we arrive at the generalised Normal distribution of Fig. 2, based on the first and second columns of Table III. Column A and Fig. 3 A show the corresponding distribution of piecepart dimension x,

TABLE III.—*Four Specific "Normal" Frequency Distributions, of Different $\bar{X}$ and σ, constructed from the Numbers 00–99*

Cell mid-point, t.	Numbers from 00 to 99 assigned to cell.	Variation x in 1/10ths of 0·001in. A.	B.	C.	D.	Cell frequency, f.
$-2{\cdot}5$	00	-25	-15	-40	-30	1
$-2{\cdot}0$	01–03	-20	-10	-32	-22	3
$-1{\cdot}5$	04–10	-15	-5	-24	-14	7
$-1{\cdot}0$	11–22	-10	0	-16	-6	12
$-0{\cdot}5$	23–39	-5	$+5$	-8	$+2$	17
$0{\cdot}0$	40–59	0	$+10$	0	$+10$	20
$+0{\cdot}5$	60–76	$+5$	$+15$	$+8$	$+18$	17
$+1{\cdot}0$	77–88	$+10$	$+20$	$+16$	$+26$	12
$+1{\cdot}5$	89–95	$+15$	$+25$	$+24$	$+34$	7
$+2{\cdot}0$	96–98	$+20$	$+30$	$+32$	$+42$	3
$+2{\cdot}5$	99	$+25$	$+35$	$+40$	$+50$	1
Mean value, $\bar{x}$		0	10	0	10	$N=100$
Standard deviation, σ		10	10	16	16	

which thus constitutes our model of the quality-controlled product. All the pieceparts produced fall inside the tolerance range $\pm 0{\cdot}003$in. In other words, the production process yields no "defectives."

What would the quality control charts for this particular process look like? Here, again, Tippett's random sampling numbers provide the answer. Assuming the control charts to be based on the inspection of periodic samples of five pieceparts, we can take, say, columns 1 and 2 on the first page of the Tippett table (*cf.* Table II) to obtain ten such samples to represent the results of process inspection. The method of procedure, using the second and third columns of Table III, is shown below.

These sampling results, corresponding to the routine inspection of the quality-controlled process defined by Fig. 3 A, are summarised in section (A) of Table IV, and are given in detail in section (A) of the upper diagram in Fig. 4. As is to be expected, the latter shows all the fifty inspected pieceparts falling inside the given manufacturing range. The process average, or grand average of all the sample averages $\bar{\bar{x}}$, is found to be a shade under the nominal dimension aimed at ($\bar{\bar{x}}=-0{\cdot}2$ ten-thousandths of an inch). The mean range for all ten samples is found to be $\bar{w}=21{\cdot}5$ ten-thousandths, or just over $0{\cdot}002$in., giving an estimated standard deviation for the process of $\hat{\sigma}=(\bar{w}/d_2)=9{\cdot}24$ as compared with the true value of $\sigma=10$.[14]

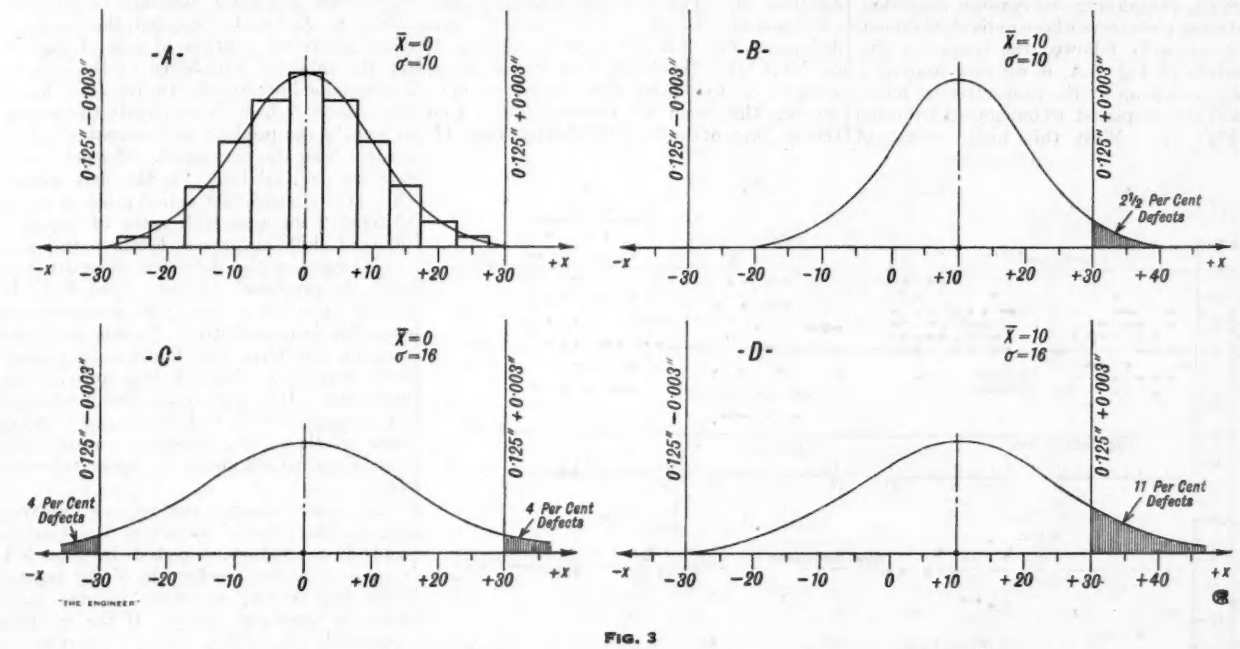


FIG. 3

Sample number.	Tippett numbers.	Deviation from nominal dimension, x.	Sample mean and range.
1	29	− 5	$\bar{x}=-6$
	41	0	
	27	− 5	
	05	−15	$w=15$
	27	− 5	
2	58	0	$\bar{x}=+6$
	92	+15	
	20	−10	
	95	+15	$w=25$
	82	+10	
10	47	0	$\bar{x}=-4$
	04	−15	
	49	0	
	49	0	$w=15$
	23	− 5	

[12] The range is defined as the difference between the highest and lowest values encountered in the sample. It is widely employed in control chart work as a measure of variability in place of the standard deviation s, but its use is limited to samples of less than from 10 to 15 items. For an example illustrating the equivalence of w and s in the control chart method, see B.S. 1008—1942, pages 17 and 19.

[13] In control chart work it is conventional to take the limits $\bar{X}\pm 3\,\sigma$ as defining the boundary between random and non-random variation. We are here assuming that this zone of random variation completely occupies the specified range of manufacturing tolerance for the quality characteristic x.

[14] *Cf.* Section 7 and Table I of Appendix A to B.S. 1008—1942; also Section 5 (*d*), Paragraph (i,)i of B.S. 600R—1942.

Here we have at first hand an experimental verification of the well-known fact that, under conditions of statistical control, the inspection of a number of small samples provides all the essential information contained in the results of a detailed inspection of the product.

The control limits for the "mean" chart are given by $x=\bar{\bar{x}}\pm A_2\bar{w}=+12\cdot2$ and $-12\cdot6$, whilst the corresponding limits for the "range" chart are defined by $w=D_3\bar{w}=0$, and $w=D_4\bar{w}=45\cdot4$.[15] The two control charts are shown in section (A) of the middle and lower diagrams of Fig. 4. As is to be expected, all the plotted points fall within the control limits defining the zone of random variation in each chart.

Experiments Introducing Uncontrolled Conditions

The practical value, particularly from the illustrative standpoint, of a control chart model such as that just described is that it lends itself readily to the identification of assignable causes, when these are artificially introduced alongside the chance causes productive of controlled product quality. For example, considering our capstan operation, producing pieceparts whose individual dimensions originally followed the frequency distribution of Fig. 3 A, if we now assume a change in set-up by the tool setter we might obtain the displaced frequency distribution of Fig. 3 B. With this high setting of +0·001in., it will be seen that the production process will in the long run yield 2½ per cent. of "defectives," for one-fortieth of the total area under the displaced normal curve falls outside the upper tolerance limit.

[15] *Cf.* Section 15 and Table I of Appendix A to B.S. 1008—1942; also Sections 6 (c), and 6 (d), Paragraph (iii), of B.S. 600R—1942.

What will the quality control charts for this production process look like now? We can again use Tippett's random sampling numbers to obtain the answer. In this case we have $\sigma=10$ as before, but $\bar{X}=10$ instead of zero, so that the individual piecepart dimensions will be $x=10+10t$, as given by equation (4). The resulting samples values corresponding to the altered process conditions of Fig. 3 B are given in column B of Table III. To obtain a succession of ten samples of five from the altered product, we take this time, say, columns 5 and 6 on the first page of the Tippett table (*cf.* Table II) and proceed as before. The results of this experimental process inspection are summarised in section (B) of Table IV, and are given in detail in section (B) of the upper diagram in Fig. 4. The effect of the shift in level is at once apparent, one piecepart in each of samples Nos. 16 and 20 falling on the upper tolerance limit. The process average in this case is found to be $\bar{\bar{x}}=10\cdot6$, as compared with the true value $\bar{X}=10$; whilst the standard deviation estimated from the mean range ($\bar{w}=23\cdot0$) is found to be $\hat{\sigma}=9\cdot89$, as compared with the true value $\sigma=10$.

The control charts for sample means $\bar{x}$ and ranges w are depicted in section (B) of the middle and lower diagrams respectively of Fig. 4. As is to be expected, the "range" chart shows no evidence of lack of control, for the inherent variability of the process has remained unaltered. On the other hand, the "mean" chart shows clearly the change in level of the product, and indicates lack of control from the very start. The point outside the control limit for the first sample (No. 11) indicates that action must be taken to remove the assignable cause of variation (upward shift in process level, in this particular case) or else defective pieceparts will surely be produced. As seen from Fig. 3 B, two or three out of every 100 pieceparts are expected to be defective. In this particular case, no defectives were found in fifty pieceparts produced, although two were on the borderline. It is quite likely that if a further ten samples of five had been taken, two or three of these fifty pieceparts would have been found to fall above the upper tolerance limit.

Let us now consider another case. Reverting to our original model of the quality-controlled product, depicted in Fig. 3 A, suppose that the mechanism of the capstan lathe had in the meantime become badly worn or otherwise faulty. If the resulting increased variability of its production amounted to, say, 160 per cent. of the original figure, we should obtain the frequency distribution of Fig. 3 C. It will be seen that with this wider range of variation in the production process some 8 per cent. of defective pieceparts will be produced in the long run, for one-twenty-fifth of the total area under the shallower normal curve falls outside each tolerance limit.

How will this new situation show up on the quality control charts? In this case we have $\bar{X}=0$ as before, because the general process level has remained unaltered, but the standard deviation of the product has become $\sigma=16$. The dimensions of the individual pieceparts produced will thus be $x=0+16t$, as given by equation (4), leading to the x-values of column C in Table III for the altered process conditions of Fig. 3 C. Taking this time, say, columns 3 and 4 on the first page of the Tippett table (*cf.* Table II) and proceeding as before, we obtain ten more samples of five to represent the results of process inspection of the altered product. The sample means $\bar{x}$ and ranges w are given in in section (C) of Table IV, whilst the individual sample values x are shown in section (C) of the upper diagram in Fig. 4. The effect of the increased variability inherent

TABLE IV.—*Sampling Results for the Production Process of Table III*

Control chart.		Means and ranges for successive samples of five.										Mean values.	
A	$\bar{x}$	−6	+6	−4	+3	+10	+3	+2	−5	−7	−4	$\bar{\bar{x}}=$	−0·2
	w	15	25	20	20	20	35	20	25	20	15	$\bar{w}=$	21·5
B	$\bar{x}$	+14	+7	+8	+8	+12	+15	+12	+6	+12	+12	$\bar{\bar{x}}=$	10·6
	w	25	20	15	15	25	25	20	30	25	30	$\bar{w}=$	23·0
C	$\bar{x}$	+1·6	−1·6	0	−11·2	+8·0	−4·8	−4·8	−3·2	−1·6	−1·6	$\bar{\bar{x}}=$	−1·6
	w	16	40	24	24	32	40	24	48	56	24	$\bar{w}=$	35·8
D	$\bar{x}$	+11·6	+13·2	+5·2	−2·8	+19·6	+14·8	+11·6	−1·2	+14·8	+14·8	$\bar{\bar{x}}=$	10·2
	w	24	24	48	32	40	56	32	32	40	48	$\bar{w}=$	37·6

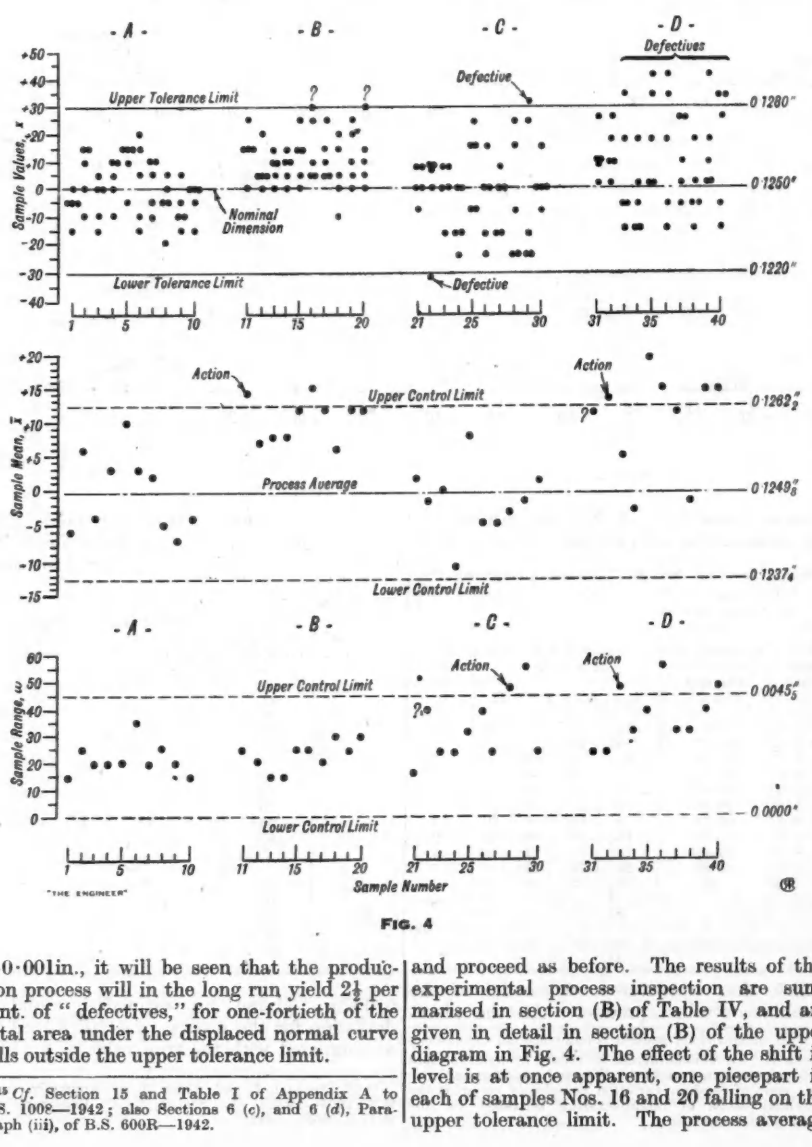


FIG. 4

in the production process is clearly seen as a more widespread scattering of the individual sample values about the nominal dimension of 0·125in. As a result, two of these values (in samples Nos. 22 and 29) fall outside the tolerance limits; that is to say, two pieceparts are defective. The expected number, as may be seen from Fig. 3 *c*, is four, two outside each tolerance limit. Had a further ten samples of five been taken, it is quite on the cards that six of these fifty pieceparts would have been found to be defective.

The quality control charts for the new process conditions are depicted in section (C) of the middle and lower diagrams in Fig. 4. As is to be expected, the chart for "means" shows no indication of lack of control, for the general process level has remained unaltered. The chart for "ranges," on the other hand, shows clearly the increased process variability and indicates lack of control by the points for samples Nos. 28 and 29 falling outside the control limit. As a matter of fact, point No. 28 is the first call for action to be taken to eliminate the assignable cause (increased variability of product, in this particular case), if the production of defectives is to be avoided, and the very next sample already includes one such defective (see upper diagram in Fig. 4). What about the corresponding occurrence of a defective item in sample No. 22? A glance at the "range" chart shows point No. 22 to be just inside the control limit, a fact which serves as a warning of impending trouble. At any rate, it may be taken as evidence of a marked change in process variability, but the evidence is not quite strong enough to call for action to be taken. This particular illustration is a good example of the argument in favour of having two pairs of control limits on the quality control chart—the outer pair serving as "action limits" and the inner pair as "warning limits."[16]

As a final illustration of this use of model quality control charts, let us consider the case where the assignable causes of Figs. 3 B and 3 C are operative simultaneously. As indicated by Fig. 3 D, the production process under these radically altered conditions is expected to yield 11 per cent. of defectives in the long run. In this case we have $\bar{X}=10$ and $\sigma=16$, so that the individual piecepart dimensions are given by $x=10+16t$. The resulting x-values are shown in column D of Table III. Taking columns 7 and 8 on the first page of the Tippett table of random sampling numbers (*cf.* Table II) and proceeding in the same way as before, we obtain another ten samples of five. The results of this experimental process inspection are summarised in section (D) of Table IV, and are given in detail in section (D) of the upper diagram in Fig. 4. The corresponding quality control charts are shown in section (D) of the middle and lower diagrams in Fig. 4. The number of defectives produced in this case is as high as eight, or 16 per cent., where 11 per cent. were to be expected. Lack of control is this time clearly indicated in both control charts, for both the general process level and the process variability have been altered. A warning point is actually obtained at the very start of the control chart for "means" (sample No. 31).

For purposes of lecture demonstration, the "ticket sampling" method may be more convincing than the use of Tippett's random sampling numbers. In that case four sets of 100 tickets, or, better still, metal-edged circular price tabs, are required, each set being marked A, B, C, or D on the back. The number of tickets to be marked on the front with each x-value is then found from the last column in Table III. Alternatively, one set of 100 tickets can be used, numbered from 00 to 99, and the required x-values can then be obtained from the second column in Table III as when using the Tippett table.

(To be continued)

[16] This is the standard practice adopted in B.S. 600R—1942.

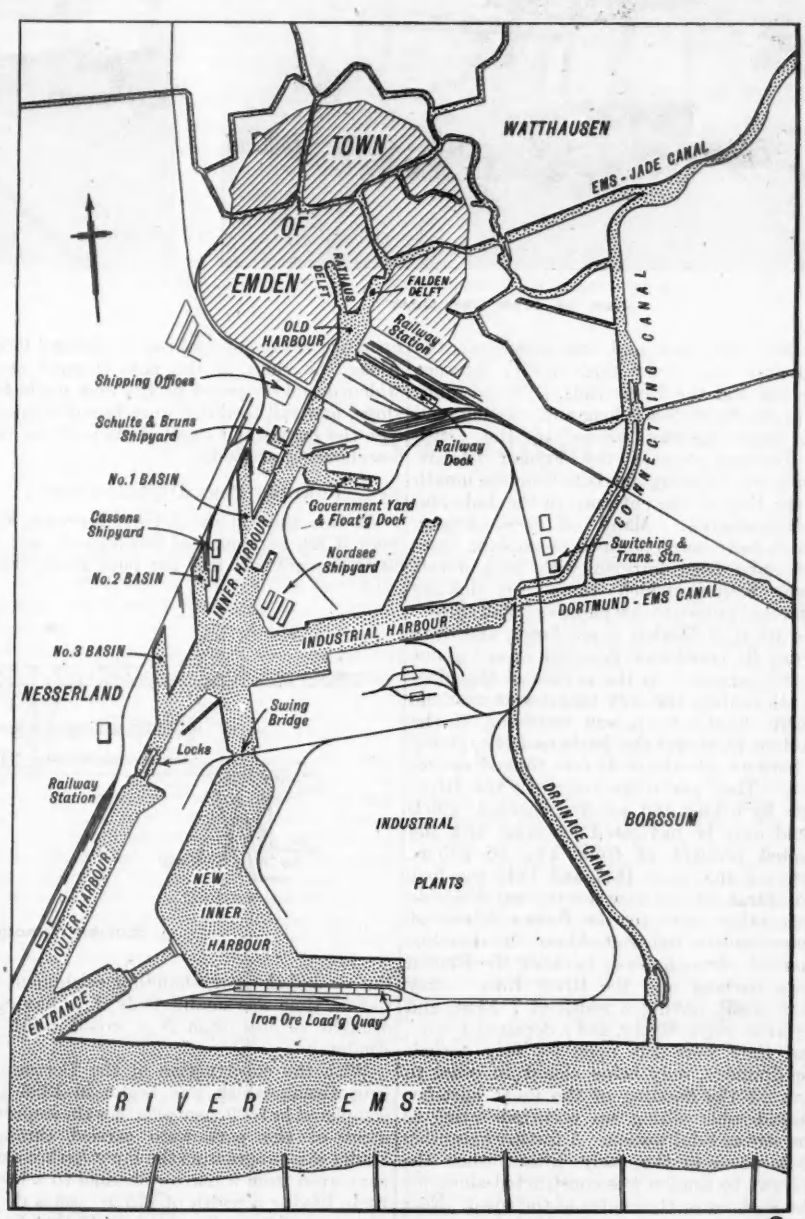
Air Force Targets

No. XXVIII

(Continued from page 306, April 10th)

THE PORT OF EMDEN

IN one of our early target articles, published in our issue of August 9th, 1940, we dealt briefly with the port of Emden, and stressed its importance in the chain of inland waterways in Northern Germany, which is still playing an effective part in the transport of war supplies. Not only is Emden at an important junction in the system of inland water transport—the Dortmund-Ems and the Ems-Jade canals meet there—but it also receives large supplies of timber and iron ore from Scandinavian countries. With the object of countering as effectively as possible the activities of the port, air attacks upon it and its military objects have been continued each month since July, 1940, and often several times a month, not only by means of special raids of bombing aircraft, but also by outward-bound or returning aircraft, which used Emden as a secondary target. One of the heaviest of the recent attacks on the town and port took place on the night of Monday, June 22nd. In this attack and in that which was made on the night of Saturday, June



MAP OF THE PORT OF EMDEN

6th, many of our large four-engined heavy bombers, such as "Lancasters," "Stirlings," and "Halifaxes," took part. Those attacks, the Air Ministry report says, must be linked with the recent work of the Bomber Command in many parts of Germany designed to destroy and damage Germany's submarine production yards and the factories such as those at Augsburg and Cologne, which make submarine engines and ancillary electrical equipment.

In view of these important measures, some further details of the port of Emden and its shipbuilding and shipping facilities may be of interest to our readers.

Early Harbour Works

The history of Germany's most western port dates back to earlier than 1850, when the harbour was open and was subject to the ebb and flow of the tides in the entrance channel and the River Ems. The entrance from the North Sea is long and winding, and the main fairway passes to the south of Borkum, one of the Frisian islands, which stretch along the coast from the mouth of the Ems to the entrance to the Jade and Wilhelmshaven. Many of these Frisian islands have been equipped as seaplane bases and have been fortified with anti-aircraft guns, besides which there are floating batteries, known to our pilots as "flak ships." The town of Emden is not large, and even to-day its population does not exceed about 35,000 persons. In the middle of the nineteenth century the only basins were near the centre of the town and consisted of the Faldern Delft and the Rathaus Delft, giving a harbour of about 40,000 square metres area. This was connected with the River Ems by a long and winding channel, which could only be navigated by ships with the limited draught of from 3 m. to 3·5 m. Between the years 1847 and 1849 the first two entrance locks were constructed alongside each other near to the former island of Nesserland on the west side of the entrance channel, about halfway between the Emden town harbour and the River Ems. They were small, having a width of 7·53 m. and 10·67 m. respectively, and a depth of 4·5 m., and they were left open for long periods for drainage, only being closed in order to prevent the flooding of the inner harbour. Considerable silting up occurred owing to the strong tidal waters. A further extension took place in the early 'fifties, when the railway to Emden was constructed alongside the harbour at the centre of the town. Near to the railway station a 145 m. quay was built along a new railway dock basin, with an area of 25,000 square feet; this was connected with the main channel by an entrance lock having a width of 10·5 m. and a depth of 4·5 m. The lock enabled the full depth of water to be maintained at the high-tide level.

The construction of the Wilhelmshaven naval base and the Ems-Jade Canal about 1880 saw further improvements made in the Emden harbour and its connections with the canal and the River Ems. These included the construction of a new and larger tidal lock near to Nesserland, having a length of 120 m., a breadth of 15 m., and a depth of 6·7 m., corresponding with the depth of the River Ems about that time. The outer harbour entrance was dredged to a depth of 7 m. and the inner harbour to a depth of 5·5 m. Silting up was prevented as far as was then possible by the provision of sluicing openings in the gates of the Nesserland lock. Along the sides of the new channel thus widened and deepened berths were made for ships, and rail facilities were brought alongside the berths and small sheds built for the warehousing of goods.

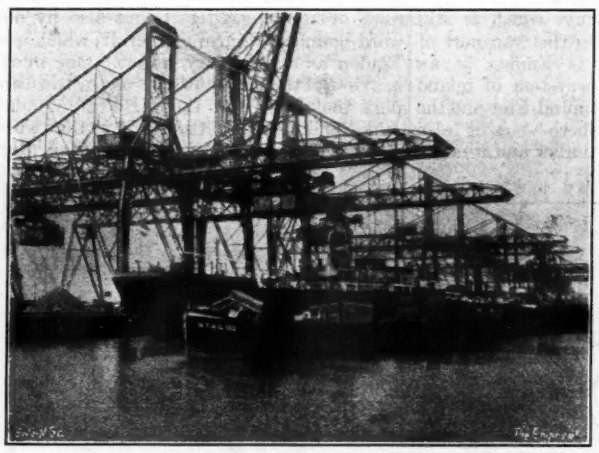
Further Port Developments

At this time in its history, however, the port of Emden remained but a small port of little account. It had but poor access from the sea and the cargo-handling equipment up to that time was small. Only ships having a draught of less than 5 m. could berth at Emden.

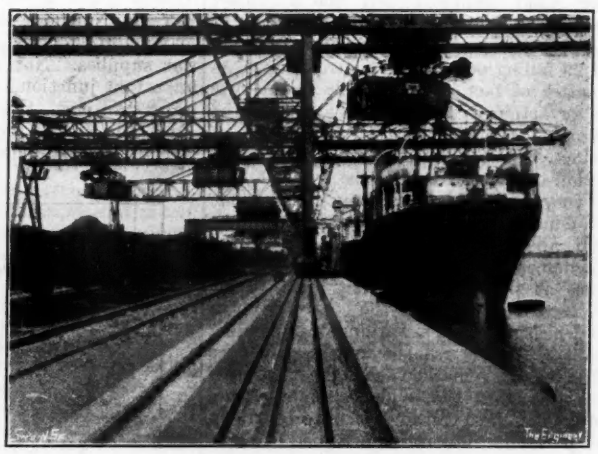
With the construction of the Dortmund-Ems Canal, which was begun in 1886 and completed in 1899, new plans for the improvement of the port were carried through. Under this programme the inner harbour was converted from a narrow channel to a broad basin having a width of 175 m. and a depth of 5·5 m. to 7 m. The Dortmund-Ems Canal entered the inner harbour at a point about halfway down its length on the eastern side. On the western side three new basins were built, and a depth of 6 m. of water was provided, land being made available for warehouse accommodation and industrial undertakings, such as ship and boat building yards. At this time the total area of the harbour to the railway bridge was about 250,000 square metres excluding the areas of the new basins.

For the transfer of goods from the barges and ships using the Dortmund-Ems Canal a small quay was constructed with sheds of 1660 square metres capacity, and was fitted out with portal type cranes. These were electrically operated, the power being obtained from a power station near Nesserland. Additional crane power was made available by the use of four 3-ton floating steam cranes. A special connecting channel was built, which entered the outer harbour below the tidal locks. In order to protect the outer harbour from mud it was enclosed by high moles.

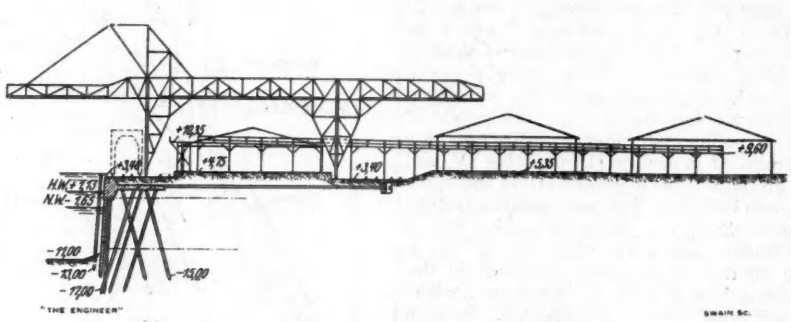
Competition with the harbour of Rotterdam, which provided at that time accommodation for deeper-loaded ships, led to plans for making Emden more suitable for larger ships. For this purpose the outer harbour was planned and built to provide water 11·5 m. in depth, so that ships drawing up to 8 m. could be kept floating even at low spring tides. The length of the outer harbour, shown on the accompanying map, is 1400 m., with a breadth of 94 m. On the west side of this extension a mole built on piles was formed, running for a length of 215 m. and connected with a quay wall having a length of 815 m. The warehouse accommodation comprised two sheds with areas of 3600 square metres and 7200 square metres respectively, and to serve these suitable cranes, along with a coal tipper and a



VIEW OF IRON ORE QUAY



UNLOADING ORE FROM SHIP



SECTION THROUGH SHEDS AT DELFZIL

40-ton lifting crane, were provided. The outer harbour also has some 1200 square metres of space for the outside storage of goods, and there are three loading bridges for the handling of coal, coke, iron ore, and similar bulk materials. On the east side of the outer harbour berthing places for thirteen or fourteen ships are provided. This part of the port is well served with railway connections, and near the locks there is a special Emden Outer Harbour Station, from which it was formerly the practice to handle the large tourist traffic from Emden to the island of Borkum and the other Frisian Islands. At the beginning of the twentieth century the earlier method of preventing silting by flushing the entrance channel was abandoned, and suction dredgers were used to maintain deep water in the harbour.

With the continued growth of the Hamburg-Amerika and the North German Lloyd mercantile fleets and the general increase in German shipping business, still further improvements to the harbour at Emden were begun in 1904, when the new inner harbour on the east side of the entrance channel was built and the new industrial harbour near the entrance of the Dortmund-Ems Canal. The new entrance lock, which has a length of 260 m., a breadth of 40 m., and a depth of 13 m., was one of the first works of its kind to be constructed on the Siemens ground water lowering principle. For this work a large number of electrically driven pumps was employed, and it was soon found that the existing power station at Nasserland was too small. Supply was taken from the new power station of Wiesmoor, through new transformer and switching stations built in suitable parts of the port.

The new harbour basin thus formed is connected to the entrance locks by a swing bridge, which carries both railway and road. With the construction of the new inner harbour modifications were made to the drainage canal system, which now has its outlet at the Borssum sluice on the Ems. During the last war some modifications were made to the entrance lock near Nesserland, which was converted for electrical working and deals with all the small traffic. New loading and unloading bridges up to 12·5 tons capacity were added to the inner harbour and came into operation about 1918.

The changed economic conditions after the war resulted in the loss of the Lorraine ore deposits, on which the Dortmund blast-furnaces had long depended, and increased amounts of iron ore had to be imported from Sweden. Between 1924 and 1937 the ore-unloading quay was considerably extended and was lengthened a further 480 m. Five loading bridges with 5-ton grabs were installed, and also four loading bridges with upper revolving cranes having capacities of 6·5 to 9·1 tons. Views of these loading bridges on the iron ore quay are reproduced in the accompanying engravings. This part of the port is mainly concerned with the discharge of cargoes of coal, iron ore, and iron and steel.

In order to deal effectively with the repair of the equipment and its single-phase motors a special repair shop was built. About 1925 further additions of two 8-ton floating cranes were made. In 1930 the power station at Nesserland was dismantled and was replaced by larger switching and transformer stations, which were built at points in the inner and outer harbours and near the entrance locks. These are connected by a 20,000-volt cable to the Emden feeder network at the Nordwestdeutschen power station on the Borssum sluice. For the transforming of the A.C. supply to D.C., which is employed for many of the motors and some of the lighting, rectifiers are used.

THE PORT OF DELFZIL

Quite near to the port of Emden and a little to the south when entering the Ems estuary, is the Dutch port of Delfzil, in the province of Groningen. This port has been used as an alternative to Emden since the occupation of Holland by Germany. It has well-designed equipment for the unloading and storage of goods, and the accompanying drawing shows a section of one of the quays constructed about 1925, with the arrangements of portal type cranes and loading bridges. Naturally, this port is on Dutch territory, and British air attacks have been few, and only such as would damage German ships using the port and the goods they discharged for transfer to works in Holland and Germany.

AIR RAID DAMAGE AT EMDEN

Recent reports made by our reconnaissance aircraft establish that heavy damage has been caused by the series of attacks made on the port and the town. Large areas of the town have been devastated. In particular, the main railway station and the outer harbour station have been severely damaged by fire. Among the shipyards which are damaged heavily, both by high-explosive bombs and fire, is the shipyard and engine works of the Nordseewerke Emden G.m.b.H. It was founded in 1904 and in 1911 became associated with the Deutsch-Luxemburgischen Bergswerks und Hütten-Aktiengesellschaft, of Bochum. In recent years it has become part of the Phœnix section of the German Steel Combine, and is closely associated with the industry of the Ruhr. It is designed to build and repair ships up to 500ft. in length, and for this purpose it has six building berths. Its floating docks include one of 5500 tons capacity and the fitting-out crane is designed to lift 65 tons. The shipyard, engine works, and stores are extensive, and it is believed that besides carrying out its normal work of constructing and repairing canal barges, sailing vessels, fishing craft, dredgers, and floating docks and pontoons, it has played its part in the building and repair of submarines. The works, which are built on the corner of the industrial harbour, have an area of about 300 acres, with a water front of over 750 yards. Other smaller shipyards on the basins of the inner harbour are those of C. Cassens on the second basin, which is a well-equipped repairing yard, and general engineering works and of Schulte and Bruns, which is above the first basin. This is a larger yard with facilities for building and repairing small ships of all kinds. It is complete with a floating dock, and at this yard ships up to 1350 tons have been built.

Nearer the town of Emden and not far from the inner harbour is a block of offices and warehouses of German shipping companies, and in this area considerable damage has been done to the Hamburg-Amerika Line offices. Among other parts of the port which have been bombed on one or more occasions we may mention the Government shipyard and floating dock.

From the above it will be gathered that the repeated bombing of this particular port has caused considerable damage to a harbour very useful to Germany, not only for the building and repair of seagoing and canal vessels, but also naval craft, and, what is perhaps of more importance, the handling of her much-reduced and much-needed import trade.

British Association

No. I

ON July 24th and 25th the British Association held a conference at the London School of Hygiene and Tropical Medicine on "Mineral Resources and the Atlantic Charter." Sir Richard Gregory, President of the Association, opened the conference with the following address :—

OPENING ADDRESS BY SIR RICHARD GREGORY

It was the great British scientist, Michael Faraday, son of a blacksmith, who began the study of the effects of metallic additions to cast steel with the object of obtaining better cutting tools and metals which would not corrode. He made a good nickel steel and also a chromium steel similar to the rustless steel discovered nearly a century after his time. Towards the end of the nineteenth century another Englishman, Sir Robert Hadfield, undertook similar systematic investigations of the effects of various metals in the composition of iron and steel. He discovered that the element manganese, when used in the composition in suitable proportions, produced a remarkably tough steel having high strength and great resistance to abrasion and wear. His production of manganese steel may be said to mark the beginning of the age of special alloys and to have given new significance to the mineral resources of many metallic elements formerly regarded as of purely academic interest.

The chief elements thus used in the production of special steels are chromium, nickel, manganese, tungsten, molybdenum, silicon, vanadium, cobalt, and aluminium. In addition to ferro-alloys, there are also numerous non-ferrous alloys in which such common metals as copper, tin, lead, nickel, zinc, aluminium, and magnesium are the main constituents. An unfamiliar metal used in the composition of one of the most important of these alloys is beryllium—an element which was isolated more than a century ago, but did not become of industrial importance until about 1935. When from 2 to 3 per cent. of beryllium is mixed with copper, an alloy is obtained as hard as steel and with high resistance to corrosion and continual stresses. The metal is extracted chiefly from the mineral beryl, one variety of which is the valuable gem, emerald. A few years ago the price of a pound of pure beryllium was £100, but improvements in methods of extraction have reduced the cost to about one-tenth and made its industrial uses practicable. Aluminium and magnesium are used in the compositions of other non-ferrous alloys on account of their relative lightness. All-metal aeroplanes are made of an alloy consisting of nine-tenths aluminium with copper, magnesium, manganese, and silicon.

Some of these elements in the composition of special alloys required for engineering purposes are widely distributed in the crust of the earth, but no country is self-sufficient in all the minerals from which essential industrial metals are extracted. This is particularly true of metals used in the manufacture of modern weapons of war. Whatever is known of the nature and distribution of common or rare mineral resources and properties of metals derived from them is the result of scientific

investigations and their technological applications. The object of this conference is to present some of these aspects of minerals and metals from scientific, industrial, and economic points of view for consideration in the post-war international policy contemplated in the fourth clause of the Atlantic Charter.

Sir Thomas H. Holland presided over the morning session on July 24th, and in what follows we print abstracts from his opening address.

OPENING ADDRESS BY SIR THOMAS HOLLAND.

Among the raw materials referred to in the Atlantic Charter minerals are, beyond question, the most important because of their natural occurrence under fixed geographical conditions which cannot be changed by any artificial measures. They are essential to all technical industries; and, rightly or wrongly, applied technology has become an inevitable and ineradicable phase of our civilisation. No civilised community can now exist without a sufficient and sufficiently varied supply of mineral products; substitutes for them cannot be provided, except to a very small degree, by other materials, natural or artificial, without increased cost and loss of efficiency. The demand for them is insistent and certainly will increase in the immediate future. The problems before us are therefore urgent.

Yet the workable deposits of useful minerals are distributed without regard to climate or established national boundaries. It follows, consequently, that, so long as difficulties are created among the nations for the exchange of such raw materials, there must always be potential friction between the "haves" and the "have nots." One can even go further without intelligent contradiction and say that, whilst tariffs can hamper international trade in mineral products, no tariff can prevent the trade altogether without the immediate creation of conditions which are certain to lead to war.

It is the speed of change in the international bearing of mineral questions which gives them special urgency. During the first thirty-seven years of this century the output of ordinary steel in the United States increased five times, from about 10 to over 50 million tons, and, to produce the output for 1937, three-fourths of a million tons of manganese ore had to be imported as one constituent among the necessary raw materials. In the latter year, with the help of a protective tariff amounting to about 100 per cent. of the import price of manganese ore, the United States did not produce enough of the ore from domestic sources to meet much more than about 5 per cent. of that country's own essential requirements.* The world is so made that the chief steel-making countries—the United States, Great Britain, Germany, France, Italy, and Japan—have little more than negligible resources of manganese ore to rely on within their own political boundaries, whilst the countries in which the mineral occurs in greatest abundance are but small consumers of it. During 1937 four-fifths of the world's output of steel occurred in countries which produced only about 2 per cent. of the required manganese.†

India is now producing about a million tons of steel annually, but uses for the purpose less than 2 per cent. of its own output of manganese ore. Russia thus becomes an outstanding exception; for many years it has been the world's chief producer of manganese, and, unexpectedly to others, during the decade before 1937 increased its output of steel ten times, thus passing from the sixth to the third position among the steel-making countries.

The argument which I have used, based on our information about the natural distribution of manganese ore in the world, is no lonely illustration of the fact that the occurrence of mineral raw materials does not coincide even approximately with the national domains in which industries have been most highly developed. There are others of a similar type on which the continuance of present civilised activities are dependent, and the American Government, wisely listening to its scientific and technical advisers, have labelled a dozen such minerals, on this account, as strategic; that is, minerals on which the States depend on outside—sometimes distant—sources, for those supplies which are absolutely necessary to maintain their essential industries and therefore to ensure safety in defence.

Manganese came into general use soon after the invention of the Bessemer process in the middle of the last century, and well over 90 per cent. of the metal produced in the world is now consumed in steel smelting. Although the metal is thus consumed only in a way analogous to that of a medicine, there is no known substitute to take its place on a large scale, and so under present war conditions it becomes a "key" product.

But out of the study of its function in this way there arose some twenty-five years later a quite different use for the metal as a definite constituent of the manganese steel which was invented by one of our distinguished members, the late Sir Robert Hadfield. And his invention of manganese steel opened up a new era in metallurgy, for it became the forerunner of a whole family of alloys of iron with relatively rare elements like cobalt, chromium, molybdenum, nickel, and tungsten.

It was the discovery and extended use of these new alloys which changed, and changed on a large scale, the problem of supplies for the industrialised Great Powers. In the last century mechanical industries sprang up around areas containing deposits of the small number of natural products required in the manufacture of ordinary iron and steel; for example, around the British coalfields, in which there occurred, associated supplies of iron ore, limestone flux, and coking coal. When the local supplies of ore became exhausted, improved transport facilities enabled Great Britain to bring iron ore from Spain and Scandinavia. But then again when ferro-alloys, with their very special and previously unexpected properties, superseded ordinary steel, their constituents had to be brought from still more distant parts of the earth, and the whole problem of commercial success in industry, as well as security in war, thus assumed an entirely new configuration. For, in addition to the family of ferro-alloys, other metallic alloys of industrial importance were discovered, such as those largely made of aluminium and magnesium, combining low density with sufficient strength for aircraft construction. Nor, indeed, is the end of this avenue of metallurgical development in sight or even predictable. Mineral products are just as essential as imported food for our continued existence as a nation; and indeed more so, because no artificial effort can grow minerals where they have not been placed already by Nature. There are not and never will be available synthetic metals for industrial use.

So far I have spoken of essential minerals in qualitative terms. When we consider the situation quantitatively the problem takes a much more serious aspect. The extension of our demands in kind is being accompanied by a correspondingly increased consumption in quantity, with one immediate and dangerous result that smaller deposits of useful minerals must be neglected for richer and larger masses which can be exploited in bulk. The pace in consumption has increased since 1900 on a scale which has resulted in a greater output than the total production of all previous history back to the Stone Age.

This matter is not mentioned as a mere curiosity of industrial history; it is to show that, with the growth of national exclusiveness in recent years, there has sprung up an increased interdependence among the nations and especially among the greater Powers, beyond the control and, one can say with safety, beyond the mental comprehension of those politicians who have had most to say, and too much influence, on the international questions which have brought us to the present condition of universal war. As one result of vague fears of aggressive trespass during the past twenty years and in spite of isolated attempts to the contrary, the nations have become more and more self-conscious, and, with regard to their natural possessions of minerals, more inclined to conserve their resources.

Failure generally to appreciate the fact that civilisation cannot go on at all without the international exchange of minerals has developed at times a general atmosphere of tension that cannot be relieved except by war. As no country can ever be self-contained in future for essential mineral raw materials, no nation can contribute its share to the progress of civilisation without the operation of principles such as those outlined in the Atlantic Charter.

Contributions by Professor H. H. Read, Professor G. B. Fawcett, and Professor P. G. H. Boswell were then presented. We print abstracts below.

THE GEOLOGICAL CONTROL OF MINERAL DEPOSITS, BY PROFESSOR H. H. READ, F.R.S.

We have a record in the rocks which make up the crust of the earth of a history of over 2000 million years. But even in this gigantic stretch of time no geological event repeats itself exactly—a diversity is at once implied. And greater diversities in the distribution and character of rocks are implicit, too, in their manner of formation.

A more or less reliable estimate can be made of the composition of the crust. Eight elements make up 98·6 per cent. of the crust, these elements being oxygen, silicon, aluminium, iron, calcium, sodium, potassium, magnesium. Of these, only aluminium, iron and magnesium are of major economic importance; all the other economic metals, such as copper, lead, zinc, tin, and so forth, are present in amount of less than one-hundredth of 1 per cent. These estimates deal with percentages of metals in the rocks of the crust. The metals in the deposits of useful minerals must therefore be only a minute fraction of the quantity of metals in the crust, this fraction having been locally accumulated by some process of concentration.

It is clear that we have to accept the geological make-up of the crust, we have to realise that nothing can be done to change that make-up, and that therefore mineral resources cannot be created by edict, command, legislation, or wishful thinking. A change in mineral distribution is not within our power, and since not even a combination such as the United Nations would be self-sufficient, Clause IV of the Atlantic Charter is relevant.

KEY METALS AND THE LOCATION OF INDUSTRY, BY PROFESSOR C. B. FAWCETT

From the beginnings of man's knowledge of metals up to about 200 years ago the number of known metals could be counted on his fingers. There were the "noble," but not particularly useful, gold and silver; and such "base" metals as copper, iron, and lead, which made up for their baseness by being useful. Mercury also has long been known. And bronze and brass were known; though it is doubtful whether their composition and their relations to copper, tin, and zinc and antimony were understood before the eighteenth and nineteenth centuries.

Such was the stock of metals known and used—in small quantities—before the dawn of science. The number now known is five times as great. But, except for aluminium, the newer metals are chiefly of importance for their part in the formation of many alloys with the older metals. And iron is still by far the most important base of such alloys, and the most important of all the metals.

The effects on human society of so great an addition to available natural resources are both complex and far-reaching. But here I wish to note only some effects of the use of the key metals on the location of industry, which is an important fact in the economic and social organisation of a modern civilised community.

The more important of these key metals include chromium, and cobalt, manganese, molybdenum and nickel, tungsten and vanadium—a list which is far from being exhaustive.

In relation to the location of industry and their effects on it, it may be noted that these metals normally occur in quantities which are

* In giving these round figures I am not unmindful of the fact that research on methods for concentrating the large deposits of American low-grade ores shows some signs of possible success in times of high prices or during the emergency of war.

† Roush, "Strategic Mineral Supplies," McGraw-Hill, 1939, page 38.

small in comparison to the ore bodies of the longer-known iron and copper, and they are found chiefly in rocks of Archean types; and so in areas away from the fertile lands of dense agricultural settlement and also away from the great coal deposits, which are not found in rocks older than the carboniferous. So the sources of the key metals are, for the most part, in remote and thinly populated areas.

Secondly, the key metals are used in small quantities, very rarely forming as much as 10 per cent. of a steel, and usually much less. So that where iron is needed in thousands or millions of tons the key metal is needed only in tens or thousands of tons.

Thirdly, in its relation to industry it is characteristic that the whole of a key metal used becomes part of the final product. The amount wasted in the process of manufacture is negligibly small.

Many of these metals are found in such a form that the metal itself is only a small proportion of the material mined. Hence there is usually a process of "concentration" at, or very near to, the mine. The location of the mine itself, and of this "concentration," is, of course, determined by the place of occurrence of the ores. But once the concentrate is obtained it is transported to existing centres of industry to be refined and then used. And it seems that the place of occurrence of the ores of the key metal has, in most cases, little or no influence on the location of the industry which uses it.

Let us consider very briefly some factors influencing the location of manufacturing industry, and their relation to these metals. Such factors may be grouped as primarily economic or social or political, though some may come under more than one of these heads.

The economic factors are chiefly those concerned with the needs for transport and power. In respect to the first, the materials to be used can be divided into (*a*) those which are wholly or mainly used up in the processes of manufacture and (*b*) those which, like the key metals, form part of the finished product. The latter must in all cases be transported from their place of origin to the final user of the product, and usually it makes little difference to cost where they are stopped on this journey to undergo the transformation from raw materials to finished goods. There is, however, a difference according to whether the user is widespread or concentrated. And in the case of the key metals it is mostly the latter, for the alloys of which they are parts are built into tools, most of which are used in industry (or armaments) and not spread widely in small lots. So there is, in general, an attraction of these materials to the regions of heavy industry, whose location has been previously determined by facts independent of these metals.

The other chief economic factor is the power required in the manufacture, though this, especially when it is in form of coal, might be classed as a "material which is wholly used up in the processes of manufacture." There is thus a great saving in reducing the transport of such power. This was the attraction which, in the palestechnic period, brought heavy industries to the coalfields, and it is still important, though the more recent electrical transmission of power has lessened the pull of the coalfields.

The chief social factors in the location of an industry are related to the amount and kind of the labour it needs. In this respect the key metals are easily classed. They are almost wholly used in industries, and sections of industries, which are dependent on highly skilled labour, and the products into which they enter go to similar industries. Hence the key metals come almost exclusively to regions of highly developed—and so generally of long standing—metal industries. And by aiding the development of, and the demand for, skilled work they tend to confirm the existing location of those industries. Up to the present, except for some Government armament industries, as in Japan, practically all the key metals are used in the two great zones of established manufacturing industries in Eastern North America and in Britain and Europe.

The political factors are very different in their effects. Here the dominant fact is that the key metals are essential to the armaments industry and to the making of tools which produce armaments. Hence in a world of independent sovereign States, no State can feel itself secure or really independent unless it has within its borders a considerable armaments industry. In fact, no State which is not an important industrial power can to-day be an important political power. Thus the political influences on the location of industries are particularly obtrusive in relation to those in which the key metals are vital, and in recent years such political forces have been of primary importance.

The economic and social factors which tend towards the location of the industries using the key metals near the centres of older metal working industries are further strengthened by the recent tendency—very prominent in steel making—to an increasing use of "scrap metal" as a "raw material," which has long been practised with the more expensive metals. A note in the *Monthly Labour Review* of May, 1935 (page 1155), states that in the U.S.A. "scrap iron and steel" formed 99 per cent. of all the materials used in steel making, and approximately half of that of the finished steel. These proportions may have increased under war conditions. They are likely to remain high and to be applied to all metals if we can attain a sanely conservative use of our metal resources. In that case we would regard the world's stock of a metal as a "revolving stock," to be used over and over again and only replenished by "new" metal to the extent needed to make good losses due to fair wear and tear and to provide for new uses.

"Scrap" is already a substantial part of the immediate raw material of these industries. But scrap is produced where metal goods are made and used, so that this part of the "raw material" comes back from the markets. Thus it tends to increase the pull of the market on the location of the industry and so to strengthen the factors which keep it in the regions of developed industry.

Some General Reflections from a Geologist, by Professor P. G. H. Boswell, F.R.S.

In order that the Fourth Clause of the Atlantic Charter ("... endeavour with due respect for their existing obligations, to further enjoyment by all States ... of access on equal terms to the trade and to the raw materials of the world which are necessary for their economic prosperity") may be implemented, what preparatory work can usefully be undertaken?

The terms of the clause are characteristically vague, perhaps necessarily so. It is trite to say that the problems that arise in the international politico-economic field bristle with difficulties. Many of these are hardly appropriate to the present conference; others, it has been laid down, need not come prominently under discussion here and now. In any case, they are the concern of appropriate experts. But there are certain geological questions which, if the discussion of mineral resources is not to be entirely academic, should be borne in mind if we are to be prepared, even inadequately, for action when the time comes.

First, in the matter of assessing the world's resources of essential minerals. All will agree that knowledge of location and quantities is a pre-requisite of action. Our information dates from pre-war days. The very character of the present world war, however, has necessitated the exploitation of mineral deposits on a vast scale and may well prove to have permanently changed the relative importance of certain resources and the location of industries; and post-war reconstruction will continue the process. Reassessment is thus necessary, but it can only be effectively undertaken after the war, when conditions once more allow of access and exploration.

Nevertheless, available knowledge forms a foundation on which we can build. Our sources of information include (*a*) publications of the Imperial Institute, Mineral Resources Bureau (mainly statistical and relating to production, imports and exports of various countries); (*b*) world conspectuses of individual minerals (such as gold, iron, copper, coal), prepared by the International Geological Congress; (*c*) publications of various official Geological Surveys, such as the Mineral Bulletins of the U.S.A., and the quinquennial reports of the Geological Survey of India; and (*d*) various reference books and papers published by scientific and technical societies. Of these, the first-mentioned are largely compilations of returns issued by various countries. Considerations of strategy and propaganda render some of the figures suspect. For example, who would trust the figures from Nazi Germany in the pre-war years? A further difficulty arises in the statements of available resources, namely, the differing connotation of the expression "estimated resources," for it is often difficult to say to what extent these are "proved" and "unproved, but probable." The propaganda value of generous estimates has not always been forgotten. In this connection the Institution of Mining and Metallurgy has for many years endeavoured to obtain clarity and uniformity in the use of language relating to such resources. As regards (*b*), (*c*), and (*d*), statistics inevitably become out-of-date with the lapse of time, but much of the information relating to the mode of occurrence of the materials and the potentialities of the various fields undoubtedly forms a valuable foundation for subsequent work. Much sorting out and collation of details will be involved, and revision of data will be necessary, but the task is laborious rather than difficult. Further, there is much valuable information about known resources and estimated reserves locked away in the archives of mining companies. How far is such confidential matter to be made available?

Investigation of mineral resources must have the twofold aim of discovering new supplies and of maintaining the activities, so far as possible, of existing undertakings. Obviously, exploration must be kept ahead of exploitation. The information presented to this conference shows—or will show—that large portions of the earth's surface have already been explored, often thoroughly so far as common minerals are concerned, but less intensively in the case of rare elements. However, there are considerable areas of which our knowledge is scanty. A decade ago we should have said that the outstanding examples were the U.S.S.R. and China, occupying respectively one-sixth and one-ninth of the earth's land surface. The U.S.S.R., fully alive to the importance of the task, has built up a geological survey with a staff of 10,000 (as compared with staffs of hundreds or less in other countries). As a result, although much remains to be done, knowledge of the mineral resources of the U.S.S.R. has increased enormously; indeed, the U.S.S.R. may prove to be the most nearly self-supporting political unit in the world as regards essential minerals. China, however, still provides vast fields for exploration, and although some of its useful minerals are being exploited, many more are doubtless latent. Smaller areas of the earth's surface are also incompletely explored; others, especially those blanketed by superficial deposits, may yield their secrets under the combined efforts of geologists and geophysicists.

In order that these areas may be examined and their resources developed, geologists and mining engineers will be needed in considerable numbers. As Britain was the cradle of geology, and as her sons have long been in the habit of penetrating the unknown in all parts of the world, it is but fitting that we should be prepared to carry on the tradition. But of late years we have been faced by an increasing shortage of geologists in this country, largely because of public unawareness of the importance of the subject and its consequent neglect in our educational system. After the last Great War, although there had been no pre-war insufficiency as now, we experienced an acute shortage of trained men. I venture to issue a warning that, after the present conflict, which has diverted many geologists into other fields of activity and denuded the universities of students in training, the deficiency will be still more serious.

(To be continued)

The Engineer

JULY 31, 1942

VOL. CLXXIV No. 4516

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ROYAL ORDNANCE FACTORIES

HASTE is almost always accompanied by inefficiency. But frequently efficiency is of less importance than rapidity of action. There are occasions when it is imperative that something should be done on the instant and when it is perilous to wait till the best can be devised. That was the position in this country when the war opened. We were short of war materials of all kinds and of the means of producing them. Hurried steps had to be taken to enrol labour and to bring factories into being. No one knew exactly what was most urgently required, nor how long it would take to produce. Nor did anyone know how much things should cost and the best means of making them. In short, our knowledge of war material production on a vast scale was almost negligible. We had, it is true, the experience of the war of 1914–18 to guide us. But that was never a total war. Attacks from the air hardly influenced output, and invasion never came perilously near. Restricted areas were few and the dispersal of factories was not necessary. The man-power problem never reached the proportions it has now attained. But, above all, the scale of operations was many times less. It is not surprising, therefore, that great mistakes have been made. There was no time to develop one consistent plan under a supreme head. A lot of authorities had to be set up in haste for specialised purposes and inevitably they trod on each other's toes. Production on the grand scale has been achieved, but at the cost of efficiency.

Many people have been severely critical of this inefficiency without, on the one hand, means of gauging it accurately, and, on the other, without giving proper study to its causes. Those faults cannot be alleged against the Select Committee on National Expenditure, which in all its reports has shown a carefully acquired knowledge of the facts and balanced judgment in its recommendations. Its latest Report, extracts from which may be found on page 96, is no exception to this rule. It is wholly concerned with the Royal Ordnance Factories and, it should be noticed, principally with filling factories. The Committee admits that its criticisms apply in a less degree to engineering factories, and we think we may add that they would apply in a still lower degree to factories owned and operated by companies. Taken by and large, the Report may not unjustly be regarded as an indictment of bureaucratic methods as applied to production. Those methods are directly associated with or directly derived from the Civil Service, and knowing how stoutly that Service defends its traditional practices, it is impossible to feel much confidence that all the recommendations advanced by the Committee will be accepted and acted upon. We may take as examples the recommendation that "the whole of the responsibility for administration, maintenance, and production in all the Royal Ordnance Factories should be vested in one person of sufficient calibre to discharge this task" and "greater responsibility should be placed upon superintendents, and their status and remuneration should be improved." Amongst other recommendations, note should be taken of the rather startling one that some of the Royal Ordnance Factories should be closed. We ask our readers to refer to the text for the arguments on which this proposal is based; but to whet their appetite we may mention that at one filling factory, according to the Report, no less than "57 per cent. of the floor space is at present lying idle." Another recommendation is that "designing staffs should pay more attention to ease and economy in producing the completed product, and no design should be accepted which has not been fully tested from the production point of view."

In all the recommendations—there are twenty-four of them—we have not found one to which industrial producers, with few exceptions, would not subscribe. The mere fact that the Committee found it necessary to make them shows as clearly as may be how far the methods pursued under Government control depart from the methods which have been developed through years of experience by industrialists. It will be noticed that with hardly an exception the Recommendations do not touch upon social or labour questions, but that almost all of them are directly concerned with management and correlated questions. Their object is to secure greater economy of labour, better utilisation of space and facilities, better direction of effort, and greater co-ordination within the organisation. These are all every-day aims amongst industrial producers, and one cannot but feel that the Committee has made a convincing case for the reform of the control of the Royal Ordnance Factories on the basis of ordinary industrial practice.

Cargo Aircraft

IT is unpleasant to learn from an announcement made by the United States War Shipping Administration that shipping losses during the week ending July 12th were the highest since the war began and that the sinkings of United Nations' vessels "have greatly exceeded new construction." We do not know what is the total current tonnage output from Allied shipyards, but it is possible to get some rough idea of it from the fact that in the United States alone ships are now being launched at an average rate of well over two per day and that before long it should reach three. The majority of these ships are of the "Liberty" type, single-screw vessels of about 14,000 tons displacement, driven by reciprocating steam engines and designed to have a very moderate speed. Contracts for more than 1500 "Liberty" ships have been placed, all to be delivered by the end of 1943. Nineteen new yards with 171 slipways in all are engaged upon the work. Our American allies have reacted in a characteristic manner to the fact that this output of new ships, supplemented by that of the British Commonwealth, is insufficient to compensate the depredations of the enemy's submarines. A recent suggestion made by Mr. Andrew Higgins, of Louisiana, and Mr. Henry Kaiser, of California—both leading personalities in American wartime shipbuilding circles—that the United States should switch over from the building of ships to the construction of large cargo aircraft has attracted great attention. The proposal is stated to be gaining considerable support among members of Congress, and a Committee of the Senate is to inquire into its practicability. Certain prominent representatives of the aircraft industry, including Mr. Glenn Martin, are said to be warmly in favour of it.

In detail the suggestion, as ascribed to Mr. Kaiser, is that the nine largest shipyards in the United States should be converted for the mass production of 70-ton cargo-carrying aircraft. The assembly lines, Mr. Kaiser asserts, could be in production within six months and maximum production, at the rate of 5000 aircraft a year, could be reached in ten months. This programme may appear highly optimistic, but it has to be noted that, according to reports received from America, some of the new wartime shipbuilding yards

—and specifically those controlled by Mr. Higgins—have been planned from the outset with the idea that later on they might be employed on the construction of large cargo-carrying aircraft as well as upon that of ships. To the objection already raised by the War Production Board that the scheme would divert materials from factories building aircraft for the armed forces, its advocates reply that an increased use of wood could be resorted to in the construction of the cargo machines. In any event it would have the compensating advantage of setting free a large tonnage of steel for use in the tank, gun, and shell factories. From the operational point of view advocates of the scheme will derive encouragement from the success which has attended the flying of bombers and flying boats from the United States to Great Britain. At the end of a year's working the R.A.F. Ferry Command announces that the aircraft lost on the way across have amounted to less than one-half of one per cent. of the total handed to it for delivery. It should, however, be remarked that if the United Nations resorted wholly or in large measure to aerial, instead of sea, transport across the Atlantic, the enemy, finding his submarines deprived of their prey, would in all probability greatly intensify his air activity over the ocean, a step which we would have to counter by providing increased fighter protection, at least in the areas nearest our shores. One important tactical advantage of the scheme would lie in the fact that munitions from the United States would be borne by air right into the heart of this country and would not require transhipment at a comparatively small number of vulnerable ports and subsequent carriage by our hard-pressed railways.

The proposal has undoubtedly a number of attractive features about it, but it requires to be demonstrated that it could "deliver the goods." It must not be overlooked that to be fully effective as a substitute for sea transport it would involve the building of several types of aircraft or at least of one type which could be readily converted for a variety of duties. In particular there would be required machines capable of carrying troops, heavy equipment, such as tanks and guns, food, oil and general cargo. From the aeronautical point of view it is not easy to see how a single design of aircraft could be made adaptable at will for the transport of these varying categories of load, while from the armaments standpoint it seems probable that modifications of design would be required to meet the exigencies of air transport—as, for example, the subdivision of heavy tanks into readily handled sections. The crucial factor is, however, the quantitative one. A 70-ton aircraft would probably have a disposable load of about 35 tons, of which about half would perhaps have to be assigned to the fuel required for the crossing. If an indirect route with intermediate landing and refuelling stations were followed—as would probably be the case—less of the disposable load would have to be assigned to fuel, but it seems doubtful whether the net cargo-carrying capacity could be increased beyond, say, 25 tons. The cargo-carrying capacity of a 14,000-ton "Liberty" ship is about 10,000 tons or a little less, but it would take about four or five times as long as the aircraft—flying indirect—to perform the trip. Quite roughly we may therefore say that in effective cargo-carrying capacity one hundred 70-ton aircraft would be required to replace one "Liberty" ship. On this basis 150,000 aircraft, or, taking Mr. Kaiser's figure, the equivalent of thirty years' output from the converted shipyards, would be required to replace the 1500 "Liberty" ships now being built or for which contracts have been let. It can therefore be concluded that as a means of providing a complete substitute for sea transport the scheme is impracticable. It seems scarcely more attractive as a means of providing a useful supplement to sea transport. The annual output of 5000 aircraft would be equivalent in carrying capacity to about fifty "Liberty" ships. This addition would be a useful addition were it really an addition. Actually it would be achieved only by sacrificing the aggregate output of ships from the nine largest yards in the United States. Those yards, we feel assured, are at present contributing more than the capacity of fifty "Liberty" ships annually to the Allied transportation resources.

Obituary

KARL OTTO KELLER

MARINE engineers, not only in Great Britain, but in America and in many countries overseas, will learn with regret of the death, on Wednesday last week, July 22nd, of Mr. K. O. Keller, director and engine works manager of William Doxford and Sons, Ltd., shipbuilders and engineers, of Pallion Yard, Sunderland. Mr. Keller, who had been ill for some weeks, died at his home, 5, The Cedars, Sunderland, at the age of sixty-five. He was a native of Switzerland and was born at Zurich in March, 1877. After six years at a primary school he attended a secondary school for a further three years, after which, as was usual in those days, he entered a general engineering works as an apprentice. On the completion of his apprenticeship in 1897 he took a four years' course at the Technical College, gaining his diploma in mechanical engineering. The following three years were spent in engineering shops in Zurich. In 1903 he took up an appointment with Kynochs, Ltd., where he was engaged in the drawing-office on gas engine development work until 1905. That year he joined the technical staff of Doxford and Sons, Ltd., and for three years investigated the possibilities of gas engines for the propulsion of ships. When these investigations were completed Mr. Keller left Doxfords to take charge of the oil engine department of Reavell and Co., Ltd., at Ipswich, which firm was then engaged on the production of small two-stroke petrol engines and four-stroke engines working on paraffin fuel. The department was closed towards the end of 1910 as by that time the air compressor business of the firm had greatly increased. In 1911 Mr. Keller returned to Sunderland to develop the opposed-piston type of marine oil engine, which is inseparably associated with the Doxford firm, and was appointed chief draughtsman and chief designer. It was largely owing to his expert knowledge and inventive genius in this branch of internal combustion engineering that the opposed-piston Doxford engine was successfully developed, and was later installed in the pioneer motorship "Yngaren" and other successful motor cargo vessels. In this early work Mr. Keller was closely associated with Mr. Robert P. Doxford and other members of the Doxford family, then in charge of the firm, and with the late Mr. Robert Haswell, who for many years acted as secretary of the engine works department and was at a later date appointed managing director of the company. Mr. Keller's inventions had to do with the constructional details of the engine, and in the later designs with the use of welded structures in the engine bed-plate and framing. With the continuing success of the Doxford design sub-licences were acquired for the construction of these engines in principal shipyards, both on the Tyne and the Wear and the Clyde. In America the Doxford opposed-piston engine has been taken up and developed by the Sun Shipbuilding and Dry Dock Company, of Chester, Pennsylvania.

It is of interest to record that during the years Mr. Keller was with the firm a total of over two million indicated horsepower of Doxford opposed-piston oil engines were installed in cargo and passenger ships.

Mr. Keller's eminence in his chosen field of engineering was widely acknowledged, and on many occasions he read papers on various aspects of marine oil engine design and operation before institutions and technical societies. He was a member of the North-East Coast Institution of Engineers and Shipbuilders, and served on its Council for many years. In 1928 he contributed a paper to the "Transactions" on "Combustion and its Difficulties in Marine Oil Engines." In 1911 he was elected a member of the Institution of Mechanical Engineers and in 1938 was Chairman of the North-Eastern Branch. His death at the comparatively early age of sixty-five will be deeply deplored by his firm and by a wide circle of friends at home and overseas.

Magnesium Production in the United States

EXPANSION of the magnesium output to approximately a hundred times the pre-war record has been announced officially by an official of the American War Production Board, since it is one of the vital light metals used in aircraft construction, bombs and other munitions. This capacity is expected to be reached in 1942 or early in 1943, the programme calling for rapid expansion of the necessary works, as in the case of aluminium, although the magnesium expansion is on a much larger scale. About 70 per cent. of the total output will be produced by electrolytic processes, 20 per cent. by the ferro-silicon process, 7 per cent. by the carbothermal process, and 3 per cent. by processes which at present are in the experimental stage. A large increase in ferro-silicon production is also necessary, since about a pound of this metal is required for each pound of magnesium produced by this method. Some of the new plants will be similar to—but larger than—plants now in operation with electrolytic treatment of sea water, the supply of raw material being unlimited, although its content of magnesium is only 0·13 per cent. Other large plants under construction will use magnesite quarried from inland deposits to produce magnesium oxide sinter in roasters. Calcined magnesia is ground and made into briquettes with coke and peat. This latter material makes the mass spongy or porous, which facilitates the penetration of the chlorine and thus aids the chlorination reaction. Other plants will use calcined dolomite as raw material. Inland salt wells are also being developed as a source of raw material, some of these striking large deposits of sand saturated with rich magnesium chloride brine. A large proportion of the total product will come from the electrolysis of fused magnesium chloride made in various ways from a number of different sources.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

THE PRESERVATION OF HISTORICAL RELICS

SIR,—Care to ensure that nothing of permanent documentary value should be allowed to go to salvage during the present drive has been publicly emphasised by the Right Hon. Lord Greene, Master of the Rolls, as President of the British Record Society, as well as by other authorities.

The Council of this Society draws attention to the corresponding need for watchfulness in the preservation by firms, public bodies, and individuals not only of documents but also of objects of enduring engineering interest. The Council had before it the case of the irreparable loss to Manchester of Richard Robert's slide lathe of 1820 which was scrapped because "the lathe was very large and not complete [this was incorrect] and was seriously obstructing our work." A more recent attempt to scrap the contents of the Wortley Ironworks, near Sheffield, particularly two unique tilt hammers (eighteenth century), has fortunately been averted by prompt action. Such danger of destruction is greatest when the salvagers are enthusiastic and ill-informed persons.

The Council appeals for sufficient delay to get advice when in any doubt. There are several quarters that can do so, which the Society will be pleased to indicate if called upon.

E. LANCASTER BURNE,
President, The Newcomen Society.
H. W. DICKINSON,
Hon. Secretary.

123, Riddlesdown Road,
Purley, Surrey, July 22nd.

AN ENGINEER'S WAR

SIR,—The letter of your correspondent who claims that the engineer is to blame for not coming out into the limelight is a great indictment against the nation and may well be the cause of some of our lack of success.

What we require most in all our activities is originality or creative thought, and the man generally who has this capacity often has little time for other work than that he is engaged on.

If an Army officer has the capacity of thinking out new and effective tactics, it is the duty of those above to appreciate his genius, and use it to their best advantage, especially if he is the type of man who cannot or does not seek the limelight himself.

We do not blame Schubert that his works lay unappreciated for so long because he was not a good publicist, and so the pleasure which millions should have enjoyed was wasted for many years.

So the creative engineer, as opposed to the executive engineer, cannot delegate creative work, and has of necessity to keep his mind on his work. Surely it is not too much to ask those who have powers of publicity and public service to make it their duty to seek out those who can and willingly would help them and the nation in the hour of need.

W. W. SPOONER,
M.A., M. Inst. C.E.

Ilkley, July 27th.

A HIGHWAY IN PERSIA.—What is claimed to be the longest stretch of road to be reconstructed in the East is now under way in Iran. The total distance to be covered is more than 2000 miles. Completion of the project will facilitate the transport of war equipment and material to the Soviet Union. Whole populations of villages are engaged on the work.

Royal Ordnance Factories

No. I

THE Select Committee appointed to examine the current expenditure defrayed out of moneys provided by Parliament for the defence services, for civil defence, and for other services directly connected with the war, and to report what, if any, economies consistent with the execution of the policy decided by the Government may be effected therein, published last week its Eleventh Report, the subject of which is Royal Ordnance Factories.

INTRODUCTION

The Committee has visited seven filling, seven engineering and two explosives factories, and taken evidence from representatives of managements and workers. It has also heard the regional directors of filling factories, the Director-General of Ordnance Factories, the Director-General of Ordnance Factories (Filling), the Under-Secretary (Labour), and other officers of the Ministry of Supply. We give below a summary of its recommendations, followed by the arguments and observations in selected cases upon which they are based.

SUMMARY OF RECOMMENDATIONS

(1) The possibility should be carefully examined of concentrating production in fewer Royal Ordnance Factories and closing the remainder.

(2) An immediate joint survey of Royal Ordnance Factories should be made by the Ministry of Supply and the Ministry of Labour in order to secure the expeditious transference of workers who are already, or soon will be, surplus to requirements.

(3) Stocks of materials and components should be accumulated in order to secure a proper flow of supplies.

(4) Designing staffs should pay more attention to ease and economy in producing the completed product, and no design should be accepted which has not been fully tested from the production point of view.

(5) Steps should be taken to ensure that components are always properly inspected before they are despatched for filling.

(6) Greater responsibility should be placed upon superintendents, and their status and remuneration should be improved.

(7) Serious consideration should now be given to the desirability of dispensing with the regional administration of filling factories.

(8) Closer and more standardised methods of measuring performance should be applied to the engineering factories.

(9) The superintendents of Royal Ordnance Factories and the managers of private firms engaged on similar work should regularly exchange records and other documentary information, and they should periodically meet and visit each other's factories.

(10) The whole of the responsibility for administration, maintenance, and production in all the Royal Ordnance Factories should be vested in one person of sufficient calibre to discharge this task.

(11) There should be an inquiry into the unification of Inspection Departments.

(12) Methods and standards of inspection should be made uniform for the various products and factories.

(13) A further reduction of inspection staff should be made at once, and if, as seems likely, no deterioration in quality takes place as the result of the introduction of incentive bonus schemes, still further reduction should be made.

(14) Statistical methods of control of manufacture should be applied to all suitable items of production in Royal Ordnance Factories as quickly as possible.

(15) Time and motion studies should be carried out and incentive bonus schemes introduced in accordance.

(16) Overlookers should be appointed from a promotion list continuously maintained to ensure that when vacancies occur every likely candidate is duly considered. This method should be extended particularly to filling factories.

(17) Hostels which are not requried by workers at Royal Ordnance Factories should be disposed of for other purposes.

(18) Where it is possible to close a hostel by concentrating the workers in other hostels, this should be done; and hostels should be made more attractive by making the various units of social organisation, clubs, &c., smaller.

(19) Greater efforts should be made by headquarters to reduce the present high rate of absence from work.

(20) Immediate action should be taken to impose the limits accepted by the Government for hours of work.

(21) A survey should be made of the skilled men who could be replaced by upgraded workers and of unskilled men who could be replaced by women.

(22) The Ministry of Supply's recruiting activities should be stopped, and the staffs at present employed for the purpose discharged.

(23) All unskilled entrants to Royal Ordnance Factories should be carefully examined so that they can be placed in those jobs for which they are best suited.

(24) A reorganisation of the Directorates at present concerned with Royal Ordnance Factories and of the Labour Division of the Secretariat should be undertaken.

There has been a large expansion of Royal Ordnance Factory capacity since the outbreak of war, and, as indicated in previous Reports of the Committee, this growth has not been free from weaknesses. The Committee's earlier criticisms were directed to the loss of workers, especially skilled workers, to other more highly paid employment; the lowness of output in relation to the resources employed; the poor quality of much of the work; the inadequacy of living and working conditions; absence from, and loss of time within, the factories; and the quality of the management. Such defects were in large part those inevitable in a great expansion of capacity based upon inexperienced labour and heavily diluted managements, and it was hoped that, within a reasonable space of time, efficiency would be considerably improved. From the evidence now collected, the Committee is glad to state that these hopes appear to some extent to have been justified, and in the last year, and more particularly within the last six months, substantial increases in efficiency and output have been achieved. In one large factory in the last six months of 1941 there has been 100 per cent. increase in output with a labour increase of only 40 per cent. The factories have not yet, however, achieved a fully satisfactory level of efficiency, and there are still grounds for criticism in the general planning and organisation, both at the headquarters and factory levels.

SURPLUS LABOUR AND CAPACITY

The Committee is seriously concerned about the amount of surplus labour and capacity in filling factories, and, to a lesser extent, in the engineering and explosives factories. In order to secure the most rapid possible expansion of output; the Ministry of Supply adopted the policy of flooding all the newly created Royal Ordnance Factories with labour, the efficient use of which was deemed a secondary and relatively long-term consideration. Filling factories were given a high labour priority, which enabled them to absorb large numbers of workers, both male and female, and, so short a time ago as the beginning of May, 1942, one of the filling factories visited was still recruiting labour at the rate of 300 to 400 persons a week. Since the factories began production considerable increases in efficiency have, moreover, resulted from the growing skill of the workers and the efforts and experience of the managements. Because at the same time no corresponding increase in programmes is being made, there is now redundant

labour in most factories. A large amount of floor space and machinery also has become surplus, both because of the change made, in the interests of shorter hours and better use of transport, from two-shift to three-shift working, and because of the increased output per operative. The amount of redundant labour and plant is likely to be largely increased during the next six months, as the result of the further improvement in efficiency (variously estimated by witnesses as 25 to 50 per cent. on present standards) expected from the introduction of piece rates, time and motion study, and improvement in lay-outs. The mechanisation of processes hitherto done by hand, and the rationalisation of production by redistribution of work so that each factory has a smaller variety of stores to fill, will lead to further increases in efficiency.

The surplus in filling capacity will be further expanded by several new factories shortly coming into production under agency agreements. Three of these factories and part of a fourth are engaged on work which could not, for reasons of safety, be done at any of the existing Royal Ordnance Factories; but in the case of two others this consideration does not apply, and work is, in fact, being transferred to new establishments from Royal Ordnance Factories which are not themselves fully employed. This fact clearly shows that, whatever may have been the need to provide this additional capacity for future requirements, the operation in present circumstances of all the factories is unnecessary and wasteful.

The dimensions of the problem are indicated by the fact that at one factory 57 per cent. of the floor space is at present lying idle. But no record of the total amount of unused capacity is kept at the headquarters of the Ministry of Supply, and the Department were unable to make more than a rough guess at the total amount in all factories. Indeed, they did not consider it their business to know. A special inquiry made at the request of the Committee revealed that the Department's guess was about half the true figure. As regards labour, one factory already has a large surplus and is expected to release 6000 workers by the end of the year. At another factory a surplus of 7000 employees is envisaged.

The question how best to use the idle floor space and machinery in filling factories is not an easy one. The shops are small and widely separated and consequently cannot be efficiently used for other kinds of production; most of the machinery is specialised and has no alternative use. On the other hand, a substantial margin of capacity must be retained against the risks inherent in handling explosives and the possibility of a sudden increase in filling programmes or of considerable air raid damage. The capacity available, however, is much greater than is necessary to meet these contingencies. Indeed, the surplus is so substantial that, if capacity were the sole consideration, it would be possible to concentrate all the production that is needed in fewer factories and to close the remainder. This would be the most desirable course, since besides facilitating the use of the surplus capacity for other purposes, it would effect a great saving of managerial and technical staffs, and other overhead charges. The Committee therefore recommends that this possibility should be carefully examined. But whether or not it is found possible to concentrate production in this way, at least some use should be made of the surplus capacity. There is at present a demand for storage space and depots of all kinds. The use of these buildings for this purpose would require little fresh expenditure and would not prevent their being later turned over to filling work if this should at any time become necessary.

For the surplus labour there is a great demand and it could be immediately transferred. Many of those at present engaged in filling ammunition possess skill urgently required elsewhere. In the factory already referred to, where a surplus of 6000 workers is expected, there were at the time it was visited 3000 miners employed, of whom 1000 had been face workers, though some of these might not be fit for return to the mines. Only one-third of the Royal Ordnance Factories engaged in engineering are working three shifts, and in seven the machine tools are far from being fully utilised, owing to the shortage of female labour. The need for labour in other industries makes the expeditious transference of the many thousands of workers who are already, or soon will be, surplus to the requirements of the filling factories a matter for urgent attention. The Committee recommends an immediate joint survey of these factories by the Ministry of Supply and the Ministry of Labour.

Supply of Materials

In spite of the redundancy of labour and capacity in the filling factories, in certain instances output falls short of the programme. The commonest cause of this was found to be the lack of a steady and sufficient supply of materials, and the same condition was apparent to some extent in the engineering factories. Conditions have improved considerably in this respect, but they still give cause for concern in the filling factories. Not only do these shortages lower output, but they lead to the inefficient working of the factories; workers are discouraged from making their full effort; and the unexpected fluctuations in supplies result in loss of time. Even if a temporary shortage of materials in one shop is met by lending the surplus labour to another, some loss of efficiency is unavoidable. Moreover, movements of this kind often give rise to considerable dissatisfaction among employees, especially when they are accompanied by a reduction in earnings.

A major reason for the uneven flow of materials is the lack of properly balanced stocks. Each factory has stocks of components, and, in addition, the Director of Storage and Distribution is supposed to hold further stocks, some in main stores for general allocation, and some which are earmarked for particular factories in what are called factory reserve stores. But for many components there are at present no such reserves. There can be no doubt that the maintenance of a regular and balanced flow of components would increase the rate of production with a consequent benefit to the fighting Services.

In some instances the components are supplied in sufficient quantity to the factory, but the design is such that they cannot be filled without a high proportion of rejects. This indicates insufficient *liaison* between design and production departments. The Committee recommends that steps should be taken to ensure that designing staffs pay more attention to ease and economy in producing the completed products, and that no design is accepted which has not been fully tested from the production point of view. The need for the closest *liaison* from an early stage between designer and producer in regard to Royal Ordnance Factory stores was stressed by the Committee as early as April, 1940 (Second Report, H.C. 113, 1939–40, paragraph 23), but the Committee's warning has apparently been disregarded.

In other cases components have not been properly inspected before despatch to the filling factories and the defects in them have remained unrecognised until the completed product reached final inspection. This results in wasted effort, since the components may have been transported over considerable distances. In some cases it has been found impossible to rectify the defect and the entire batch has had to be completely scrapped. The Committee recommends that steps should be taken to ensure that components are always properly inspected before they are despatched for filling.

Regional Administration of Filling Factories

The Committee was impressed by the competence of the majority of superintendents, but found that in many respects their authority was unduly restricted. The responsibility for many of the services and functions in Royal Ordnance Factories is vested in outside authorities. This applies not only to inspection and security, but also to canteens, hostels, transport, police, accountancy, establishments and matters of statutory regulation such as the operation of the Essential Work Order. Even the appointments to grades above foreman have to be sanctioned by higher authority, and there is often considerable delay before approval is obtained. The regional administration inevitably restricts the responsibilities of superintendents even further by taking charge of such important aspects of factory work as scientific and technical development, maintenance of machinery, planning, progressing, labour and training. The position of the Superintendent is not made easier by the fact that the regional director and his staff may also be resident in his factory. Several superintendents complained that the regional administration prevented direct approach to the Director-General of Filling Factories and direct contact with superintendents in other regions engaged on similar work. Now that the period of teething troubles is over, far greater responsibility should be placed upon superintendents and their status and remuneration should be improved (*cf.* Seventeenth Report of last session, H.C. 102, 1940–41, and the Departmental Reply in the First Report of this session, H.C. 20, 1941–42).

Devolution of greater responsibility to superintendents would not eliminate the need for co-ordination which the regional administration at present provides. But, since under the schemes of rationalisation now being put into effect, each factory will fill fewer kinds of store, and since the geographical considerations mentioned in another paragraph will no longer apply, it should be possible for superintendents, given the greater responsibility which the Committee recommends, to maintain direct relations with the others engaged on similar work.

For these reasons the Committee recommends that serious consideration should now be given to the desirability of dispensing with the regional administration. In considering this proposition the crucial question is not so much whether the regional administration is doing useful work, but whether the technical staffs which it retains would not make a greater contribution to the national effort if they were employed elsewhere.

Measurement of Factory Performance and Exchange of Information

In all Royal Ordnance Factories costs are prepared at monthly intervals. They are obtained, as far as possible, by the use of mechanical processes and are of standardised form. The figures are not, however, well suited for use in controlling labour and materials sufficiently nor in supervising the quality of output. In filling factories, but not in engineering or explosives factories, a works record scheme is now being brought into operation. This scheme secures a record of the total factory output of each store; the man-hours required per 1000 articles; the man-hours required by the factory in relation to those required by the most efficient factory in the same region, and in relation to standard man-hours as determined by time studies; the percentage of man-hours actually worked to the total booked; the percentage of stores passing inspection; and the relation between actual output and programme output.

The engineering factories supplement their costs data with records of man-hours, operation times, machine tool usage, idle time, and the like. The methods employed, however, vary considerably between factories. One of the establishments visited relied mainly on records of idle time which were examined for each shop, but were not compiled for comparative purposes; others had more elaborate systems. Precise comparison between factories is therefore almost impossible, and improvement in efficiency within the engineering factories is handicapped. Engineering undertakings present greater difficulties in this connection than do filling factories, but that the obstacles are far from insurmountable has been shown by modern industrial practice. The Committee recommends that closer and more standardised methods of measuring performance should be applied to the Royal Ordnance Factories engaged in engineering.

There is the same need for systematic methods of efficiency control in private firms as in Royal Ordnance Factories. No instance was found in the course of the present inquiry of records being kept regularly for comparative

purposes by a Royal Ordnance Factory and a private factory, although, for many articles such comparisons are both feasible and desirable.* Costs for private firms are obtained by certain Royal Ordnance Factories, but the figures are based upon costings investigations made after contracts have expired. They may therefore be out of date, and they are not prepared on a comparable basis. The value of standardised costings procedure was stressed in the Fourth Report of last session (H.C. 33, 1940–41, paragraph 28), and the Committee emphasises the importance of this in relation to the private firms engaged in the manufacture of munitions.

While there are well-organised arrangements for the interchange of information between Royal Ordnance Factories, arrangements for such interchange between them and private undertakings are not altogether satisfactory. This is an immediate consequence of the fact that the private firms and the Royal Ordnance Factories are responsible to different Directors-General in the Ministry. Some Royal Ordnance Factory meetings are attended by representatives of private firms, and *vice versâ*. But in many cases the two types of undertaking work in complete independence. The superintendent of one Royal Ordnance Factory did not know the names of the private firms engaged on the same work, let alone their methods and costs of production. The Committee recommends, first, that the superintendents of Royal Ordnance Factories and the managers of private firms should regularly exchange records and other documentary information; secondly, that they should periodically meet and visit each others' factories; and, thirdly, that it should be the duty of the appropriate Directors-General to ensure that this interchange of knowledge takes place.

Headquarters Organisation

The headquarters organisation of the Royal Ordnance Factory department is strangely lopsided. The Director-General of Ordnance Factories is responsible for the administration of all types of factories, but his responsibility for production and maintenance is confined to the engineering and explosives factories, while a Director-General of Ordnance Factories (Filling) is responsible for production and maintenance in filling factories, but has no control over administration. The staff of the former is headed by one Deputy Director-General in charge of engineering, another in charge of explosives, a director who is responsible for administration and accounts in all factories, and various officers who take charge of the different branches of production. Under the Director-General of Ordnance Factories (Filling) is a Deputy Director-General of Filling Factories, a group of headquarters officers in charge of various aspects of planning and production, and, in addition, the regional directors referred to in a preceding paragraph.

Many of the defects and weaknesses referred to in the earlier parts of this Report can be traced to this absence of unified control. A Director-General with full responsibility for all Royal Ordnance Factories would not have tolerated the presence of a large surplus of labour in filling factories at a time when many engineering factories were suffering from an acute shortage of unskilled labour. Similarly, a unified control would have ensured that the problems of regional organisation of filling factories were examined in relation to the experience of the department dealing with engineering and explosives, where direct contact is maintained between the factories and headquarters, and where control is on a functional, instead of a regional, basis. Again, similar standards of measuring efficiency should be laid down for all factories, and not independently for the three different groups. Further, the division of responsibility between the two Directors-General has undoubtedly contributed to the department's failure to rectify mistakes in planning. Although the existence of excess capacity is due to circumstances not all of which are within the control of the Department, it must be emphasised that a Director-General responsible for the whole Department would be in a much better position than two separate officers, upon neither of whom does the responsibility lie, to ensure that the provision of new capacity is properly related to programme requirements and that the most economical use is made of existing capacity. The failure to maintain a satisfactory chain of contacts was exemplified at one filling factory, where, taking into account both changes in programme and improvement in efficiency, only a 10–20 per cent. increase in labour was estimated by the management to be necessary, but headquarters put the required increase at over 40 per cent. At the same factory the output of certain stores had to be kept considerably above the planned output because the factory had been laid out for mass production, and the minimum rate of output at which it could be efficiently utilised had not been taken into account in the allocation of work. Instances such as these emphasise the weakness of the existing headquarters organisation. The maintenance of an even flow into filling factories of components and materials derived from engineering and explosives factories, the securing of well-balanced stocks of such materials, and a greater standardisation of records throughout Royal Ordnance Factories, are all matters likely to be far more efficiently dealt with under a single direction than by the present divided and curiously overlapping control now attempted by the two separate Directors-General. Piecemeal remedies can only aggravate the problems; reorganisation is required at the level from which policy is directed, and the Committee therefore recommends that the whole of the responsibility for administration, maintenance, and production in all Royal Ordnance Factories should be vested in one person of sufficient calibre to discharge this task.

Inspection

At each Royal Ordnance Factory there are one or more inspection departments responsible for inspecting the stores required by the Navy, Army, and Air Force. These organisations, which in a large factory may employ several thousand examiners, are entirely independent of the production management, and are not responsible to the superintendent. This independence is essential in order to ensure that the products of the factory conform to the standards laid down by the user Service. This does not mean, however, that the inspection departments are concerned solely to reject defective work. It is their function to help the production staff to eliminate the causes of defective work, and in suitable cases they may be able to relax standards without affecting the efficiency of the product. The Committee has no reason to believe that these functions are not generally discharged. (For criticism of a particular case, see the Ninth Report, H.C. 85, 1941–42.)

The different inspection departments maintain entirely separate organisations in each factory. There may thus be three separate departments, each with its own supervisory staff, and its own labour, welfare, and pay sections. Such an arrangement is obviously uneconomical. It involves, moreover, if delays are to be prevented, the retention by each of a margin of examiners to meet the possibility of a sudden increase in the flow of production at any point. There is thus a strong *prima facie* case for unifying these departments into a single inspectorate. Admittedly, there are difficulties in any such arrangement. Each department has its own special requirements and its own methods of training examiners. But that these difficulties are not insuperable is supported by the evidence of officers in charge of these departments, and by the fact that in some cases they already inspect on behalf of each other. The Committee believes that a complete unification of inspection services is possible, at least in relation to the products covered by Royal Ordnance Factories, and probably also in regard to many kinds of manufacture outside that field. The essential condition is that the user Services should be able to obtain their specific requirements, and this could be done by suitable arrangements for *liaison*.

There is no uniformity in the way in which inspection is carried out at intermediate stages of production. In some factories, this is done by a staff employed by the factory; at others, by the inspection departments; and again at others, partly by one and partly by the other. In the latter case there is inevitably a certain amount of duplication of inspection and consequent waste of labour. There is also evidence that there is no uniform standard of inspection of like products at different factories. The Committee therefore recommends that from the experience already gained a decision should be taken as to which methods and which standards of inspection are most desirable, and that uniformity of practice should be established for the various products and factories.

The Committee has heard some criticism from the production side at filling factories of the high proportion of inspectorial to productive personnel, particularly at the intermediate stages of production. The average ratio is about one examiner to every five productive workers, but in some shops within the factory the proportion is much higher. This apparently high ratio has up to the present been justified on two grounds. First, inspection staffs have been required to train large numbers of new and entirely unskilled workers to the necessary standards of workmanship and have thus, in effect, been themselves a direct factor in production. Secondly, a larger inspection staff had to be trained in readiness for the expansion of the factories to their full strength. Latterly, both these reasons have ceased to apply, and there has been some reduction of staffs accordingly; but there is reluctance to carry the process further until the effects of the bonus incentive scheme upon quality have been gauged. So far, however, as the present limited experience of the bonus incentive scheme goes, no deterioration of quality has yet appeared. The Committee is satisfied that a further reduction of inspection staffs is possible at once, and that if, as seems likely, no deterioration in quality takes place as the result of the introduction of incentive bonus schemes, a still further reduction should become possible.

The Committee was surprised to find that in the case of certain kinds of ammunition as much as 10 per cent. of rejects at the final inspection was considered normal. Any method therefore whereby the percentage of rejects can be reduced deserves serious consideration. In recent years considerable attention has been given to the development of statistical methods in the control of manufacture. These methods yield information which assists the producer to discover the causes of defects and even to anticipate their occurrence, with resulting benefit to output. They have been studied by the Research Department of the Ministry of Supply since soon after the outbreak of war, and the possibility of their introduction in the Royal Ordnance Factories has been investigated. In the case of engineering, it appears that the methods are difficult to apply to types of work involving a very high standard of accuracy. In filling factories, on the other hand, tests have been successfully applied to two fuses with the result that larger percentages of filled fuses are now passing proof. Other items are being studied on similar lines, and it is expected that in the near future, statistical control will become a routine for ammunition filling.

(To be continued)

* One case of interchange of efficiency records between Royal Ordnance Factories and various factories belonging to a private firm, all operating the same type of machine, was reported to the Sub-Committee on Supply Services in Session 1939–40.

Salvage of Lamp Packing Material.—The Electric Lamp Manufacturers' Association of Great Britain, Ltd., asks us to draw the attention of our readers to the urgent need for salving lamp packing material, for, if preserved in good condition, it can be used again, thus making a substantial saving in labour and material. All bulk or outer containers in which supplies of lamps have been delivered should be returned to the nearest depôt of any member of the Association, or, if there is a convenient van delivery service operated by an E.L.M.A. member, they should be handed to the carman. It is pointed out that while the individual lamp cartons should be salved and passed to local salvage authorities, it is the outer containers which should be returned to the manufacturers.

American Copper Mine and Reduction Works

No. II

(Continued from page 71, July 24th)

FINDING a site for the reduction works was a difficult problem, owing to the broken character of the mountain country, but eventually a level site for all the main buildings at about elevation 4350 was provided by cutting down ridges and filling adjacent ravines or depressions. From the primary or coarse crusher plant belt conveyors carry the product to the storage bins serving the fine or secondary crusher plant, from which other conveyors lead to the concentration plant. Since the works were started extensions increasing the output capacity by 80 per cent. have been authorised, as indicated in the general plan, Fig. 1 (*ante*). Nevertheless, there is ample room for enlarging the buildings and other facilities without crowding and without affecting the convenient and economic operation as planned originally.

Ore trains from the pit or mine enter the upper floor of the primary crushing building. The operator signals the engineman as to the spotting of each car in position for dumping, and a man stationed on the floor trips the pneumatic tipping or dumping mechanism. The ore thus discharged passes over a grizzly or bar screen set at a 40 deg. slope, the oversize material passing on to feed the 60in. gyratory crusher. The discharge from the crusher and the fine material which passes through the screen are fed by two steel pan conveyors to a pair of parallel 54in. belt conveyors which discharge into the storage bin.

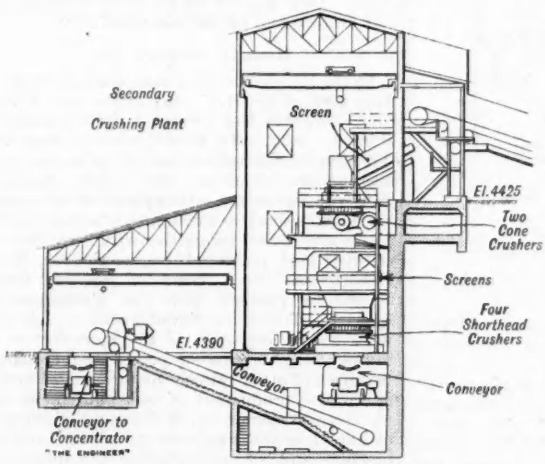


FIG 2—SECONDARY CRUSHING PLANT

The top of the crusher, into which the ore falls, has an overall diameter of 20ft., and the total height of the machine is 28ft., with free flow from two discharge openings at the bottom, so that there is no clogging of the product. It is driven by a 500 H.P. motor at 260 r.p.m. At this normal speed the crushing capacity is 2200 tons per hour for a 7in. size of product, or 2800 tons at 9in. size. About 60 per cent. of the ore discharged on the grizzly is oversize and goes to the crusher. With cars dumping at intervals of 1·4 min. and 40 per cent. of the ore passing through the screen, the crusher and the two sets of conveyors are able to take care of any future enlargement of the works.

The two steel pan conveyors which feed ore from the crusher to the belt conveyors are 72in. wide and 40ft. long, entirely enclosed in steel housing and driven by variable-speed motors through triple-reduction gears of herring-bone type. The driving mechanism is interlocked with that of the conveyors, so that if the conveyors stop the feeders also will stop. Gates on the discharge chutes are so arranged that either feeder can deliver to either or both belt conveyors. Beneath the steel pan feeders are short belt conveyors to remove ore spilled from the pans.

The two 54in. belt conveyors to the storage bin run at 475ft. per minute, giving a normal and maximum capacity of 1750 and 2300 tons per hour, respectively. The capacity is limited by safety of tension on the belts and practicable sizes of belts, but with the duplicated equipment there is the obvious advantage of continued operation while one conveyor is out of service for inspection or overhauling.

A steel-frame building houses the crushing plant and has a 100-ton overhead travelling crane for handling the heavy machine parts. This crane may serve also to handle a car in case of derailment. A separate track entering the upper floor provides for handling supplies and machine parts without interfering with the movements of the ore trains. A tunnel at the level of the belt conveyors gives direct access to the ball mill floor of the concentrator building.

Conditioned air of controlled humidity is supplied to the electrical control room and other points on the working floors, and a slight pressure is maintained in the driving or machine room. Escape of dust is minimised by maintaining a suction at all hoods, enclosures, and compartments through which the ore passes. At the dumping point dust is limited by a rubber belt curtain over the pocket and close to the cars. Steel rails closely spaced and bolted to the concrete protect the walls of the ore pockets from erosion. The train of empties passes on through the building to a tail track, where it reverses direction for return to the ore pit.

Storage of crushed ore is provided in a bin of peculiar construction, 146ft. long and 95ft. wide at top, having a capacity of some 15,000 tons. This bin, shown in Fig. 3, is formed by a side-hill cutting or trench, with the excavated rock piled on the downhill side to form a wall of triangular cross section. For good appearance and to prevent slips or sliding, the outside face of the wall, with a slope of 1 on 1, is formed by large quarry blocks placed by derricks. Upon this massive wall is a low concrete wall to support the steel roof framing. The opposite side of the bin is formed by the vertical face of the rock cutting, which is faced with concrete.

The bottom of the bin consists of a concrete structure which contains three compartments or tunnels. Two of these tunnels are for short conveyors which feed the ore to the receiving ends of lateral conveyors leading to the fine or secondary crushers. There are eight of these feeders, located under steel-lined gate openings in the roof slab. Columns on the end walls of the bins support a pair of parallel longitudinal trusses of 145ft. span, 35ft. apart. Between the trusses is the conveyor gallery, carrying the discharge ends of the belt conveyors from the primary crusher. Travelling trippers in the gallery provide for discharging the ore from the conveyors at any desired point in the length of the bin. Roofing over the side portions of the bin is carried by steel rafters sloping down from the longitudinal trusses to the side walls of the bin.

Owing to the characteristics of this particular ore, a suitable feed for the ball mills can be produced by a single pass through a short-head cone crusher, instead of requiring a screened crusher product for delivery to the mills. Therefore the design of the fine crusher plant was based on taking 25,000 tons per sixteen-hour day, in sizes from fines to 10in. or 12in. lumps, and reducing this material to a maximum size of ¾in. The arrangement of this plant is shown at the left in Fig. 2. Assuming that the plant operates only twelve hours daily, this means a capacity of a little more than 2000 tons per hour.

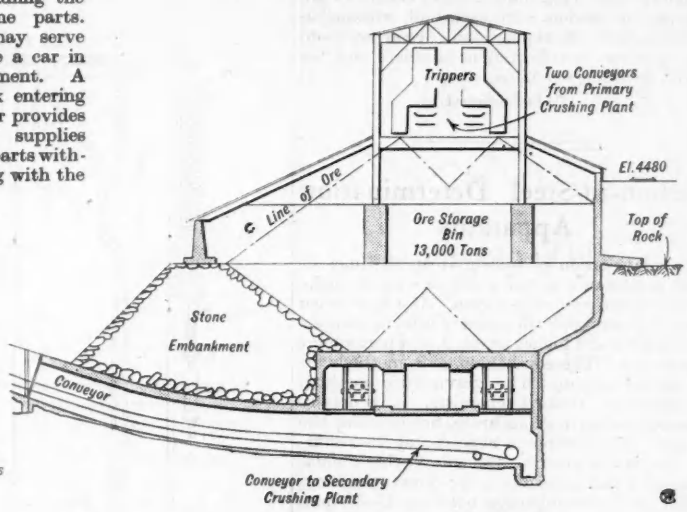


FIG. 3—SECTION THROUGH STORAGE BIN

The equipment of this crushing plant is in duplicate. Ore brought from the storage bin by belt conveyors is discharged upon an inclined vibrating screen of the rod deck type and goes to one or other of a pair of 7ft. cone crushers. Thence it flows by gravity to one or other pair of a set of four 7ft. short-head crushers. The chutes between the upper and lower crushers are made with vertical sides as far as possible, so that even with sticky material the clogging of fines will be reduced or eliminated.

For the removal of tramp iron and other foreign matter from the ore the 60in. conveyor from the storage bin passes under mushroom magnets, while a magnetic-head pulley picks off particles that may be held underneath the larger pieces of ore. Furthermore, the conveyor travels at a speed of only 200ft. per minute, which is slow enough to permit removal by hand of large pieces of iron or wood.

In the design of the concentrating plant the principal aims were to handle 25,000 tons of minus ¾in. ore daily, grind it to 2 per cent. on 65 mesh, and effect a high rate of copper recovery at a minimum cost. Besides the ore, 100,000 tons of water have to be carried through the plant daily in the treatment of the ore. Four steps of treatment are comprised in the flow sheet: (1) grinding, (2) rougher flotation, (3) cleaner flotation, (4) regrinding. The upper or ball mill floor of the concentrator is at level 4390, with the lower floor and concentrate beds at 4338, giving a vertical fall of 52ft. during the processes of treatment.

Ore from the fine or secondary crushing plant

is delivered to the overhead steel bin of the concentrator plant by a 54in. belt conveyor. The belt extends the full length of the bin, 448ft., and is served by a travelling tripper, which can be operated by hand or can be set to travel continuously back and forth, thus distributing the ore evenly. In this way the bin is supplied at the rate of 2500 tons per hour.

The ball mills are considered to be the largest ever made; each one is 10ft. 6in. long and 10ft. 2in. in diameter inside the lining, with a weight of 137 tons, including its charge of balls. They are driven at 18 r.p.m. by synchronous motors of 800 H.P. There are sixteen of these mills, each with four discharge gates. Normally one gate is open, but in case of clogging or stoppage the others are available, so that continuous operation is assured. Through these gates the ore is fed to belt conveyors parallel with the ore bin, and these in turn carry the ore to the scoop boxes of the mills. Since the discharge from the mills has to be delivered to two separate classifiers, a special discharge head was designed, having four longitudinal spiral vanes. Two of the compartments thus formed discharge through ports to one launder, while the other two discharge into a second launder. Two 54in. duplex spiral classifiers are arranged in tandem with each mill, working in closed circuit with the ball mill. Overflow from the classifiers is collected in launders and fed to the flotation machines.

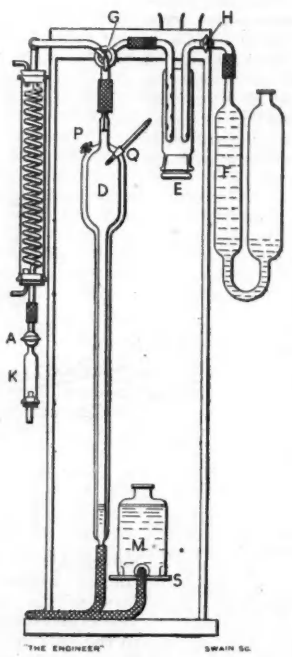
(To be continued)

Carbon-in-Steel Determination Apparatus

THE estimation of carbon is at all times of great importance to the industries which make or use steel in any of its forms. At a time when the war potential of the country is being stepped up to higher and higher levels, it is of paramount importance. There are three main methods for its determination. The gravimetric method, operated by trained chemists, is generally regarded as the most accurate, but it is also the slowest. The sample is burned and the resulting CO_2 is absorbed in Ascarite, Carbest, soda-lime, &c., and determined by direct weighing. A complete determination occupies 15–30 min. In the magnetic method a sample, tapped from the furnace, is run into a funnel-shaped mould. The magnetic properties of the stem of this specimen are examined in a type of permeability bridge. They are then correlated with the carbon content. Allowances need to be made for the presence of elements modifying the magnetic properties of the steel, but it is claimed that a determination can be carried through in 2–2½ min. The Carbometer is an instrument of this type, and the Carbanalyser is a later, more portable, and compact version, built after research work by the United Steels Corporation, U.S.A. The instruments are expensive and now difficult to obtain. The volumetric method generally employs an apparatus of the Strōhlein type. A sample of drillings is burned in a stream of oxygen, the resulting CO_2 and excess oxygen are collected in a special jacketed burette, and the CO_2 then absorbed. On passing the excess oxygen back to the burette the diminution in volume is read against a scale calibrated directly in percentage of carbon.

The volumetric method was first introduced, it is believed, in Germany, from which this country and most of the Dominions and Colonies obtained their apparatus before the war. Manufacture here is now, however, in full swing by Griffin and Tatlock, Ltd., and though production has presented some difficult glass-blowing and other problems, these have been solved and the apparatus is now generally available. The apparatus as originally devised has been greatly improved during the experimental work which has preceded British production. In the original German apparatus, a special type of KOH absorption vessel was included, similar in general form to F in the diagram, but fitted with a system of three ground-in, non-return float valves. While these valves ensured fairly efficient absorption, they, nevertheless, required the gas to be passed twice through the KOH solution for complete CO_2 absorption, and, moreover, rendered the vessel difficult to construct. The design of this vessel has therefore been modified, so that, being fitted with only one ground-in float valve, it acts merely as a gas receiver charged with KOH solution. Between F and the burette D there is now interposed a soda-lime vessel E, so constructed that CO_2 absorption occurs both on the outward passage from, and the inward passage to, the measuring burette. This means that one of the scrubbings necessary with the older type of apparatus has been eliminated. An additional stop cock A is also introduced, which enables the absorption apparatus to be isolated from the furnace, and the next sample to be preheated at the same time as the gas from the previous combustion is being measured. This feature makes a further material contribution to the speed of a determination.

In the hands of routine chemists the results are incomparably more rapid than with the gravimetric method and they are free from the uncertainties of the magnetic method. The accuracy of the method is 0·01 per cent., and a determination, it is said, requires little more



CARBON-IN-STEEL DETERMINATION APPARATUS

than a minute, though experienced operators claim twelve determinations in 10 min. Vessel E carries a charge sufficient to deal with about 2000 carbon determinations at 0·5 per cent., and *pro rata* with other carbon contents.

The apparatus consists of a polished wood stand 9in. by 14in. base by 40in. high, fitted with an iron rod provided with two sliding clamps supporting a water-jacketed burette D. The jacket is filled through the aperture P and a thermometer Q is provided. A levelling bottle M, connected to the burette by rubber tubing, is supported on a shelf S which is adjustable on the rod holding the burette. Gas is led to the burette from the combustion furnace through filter K, preheating stop cock A, and thence *vid* a glass cooling spiral into D by three-way stop cock G. The CO_2 absorption system comprises a glass vessel E with ground-in filling stopper at base secured by steel springs, and with a multi-perforated inlet tube and a single perforated outlet tube communicating through stop cock H with a single-valve gas receiver F. Three pegs are fitted to the top of the stand to locate the levelling bottle, when it is in its raised position for driving gas from the burette into the absorption vessels.

This carbon-in-steel determination apparatus is suitable for use with all types of iron and steel having a carbon content not exceeding 4·5 per cent. The sample of drillings, 1 gramme, is placed in a combustion boat and introduced into a furnace maintained at the necessary temperature. Low results are sometimes obtained when furnace temperatures of 900–950 deg. Cent. are used. For low-carbon steels a temperature of 1000–1050 deg. Cent. may suffice, but for many alloy steels 1150–1200 deg. Cent. is required, and is no disadvantage, even with low-carbon steels. A high-temperature precious metal wound furnace or a carborundum element furnace is therefore to be preferred in all cases.

Sixty Years Ago

ROBERT WILSON

IN our issue of August 4th, 1882, we recorded the death on July 28th of Mr. Robert Wilson at the age of seventy-nine. Mr. Wilson was a partner with Nasmyth in Nasmyth, Wilson and Co., of Patricroft, Manchester. He was born at Dunbar in 1803, and received a very meagre education in his early years. By dint of great force of character and mechanical bent of mind, he succeeded in reaching high eminence in the engineering profession. He took a large share in perfecting the steam hammer under Nasmyth and was responsible in his later years for the construction of a great double-acting hammer at the Royal Arsenal, Woolwich. In his early manhood he took a great interest in screw propulsion, and in 1833 submitted models illustrating his ideas on the subject to the Admiralty. That department, however, reported against the utility of the principle. Late in life he devoted his attention to improvements in the "fish" torpedo, and for his work in that direction received an official award of £500.

ROBERT CHARLES MAY

In the same issue we announced the death on July 20th of Mr. R. C. May at the age of fifty-four. Mr. May was born at Ampthill, Bedfordshire, in 1829. His father, Charles May, was "a man of remarkable native practical engineering ingenuity, and one whose ingenuity grew rapidly in the atmosphere of splendidly varied experience in which men of ability moved and worked hard during the early busy years of railway and collateral engineering." When Robert was seven years of age his father became a partner with the Ransomes, of Ipswich. The firm's Orwell works at that date were chiefly engaged on the manufacture of railway wagons, chairs, points and crossings, bridges and other railway requirements, as well as on the production of mill equipment and agricultural machinery. Robert was apprenticed at the Orwell works, rose to become outdoor manager and left to take up an appointment as resident engineer on the South-Eastern Railway. In 1854 he settled in London as a consulting engineer, where he soon acquired a considerable practice in gas, mill, and railway engineering. In his later years he turned his attention to mining work.

NEW BRITISH CHEMICAL STANDARDS.—The Bureau of Analysed Samples, Ltd., Markington, Harrogate, announces two new British Chemical Standards steels, viz.:—

13 per cent. Chromium Steel, No. 211	Per cent.	*0·3 per cent. Lead Steel, No. 212*	Per cent.
Chromium	13·81	Lead	0·28
Carbon	0·247	Carbon	0·415
Silicon	0·29	Silicon	0·13
Sulphur	0·010	Sulphur	0·023
Phosphorus	0·017	Phosphorus	0·054
Manganese	0·34	Manganese	0·73

Each sample has also been analysed for minor elements, such as As, Ni, Cr, V, Ti, and Cu. The 13 per cent. Cr steel No. 211 will serve as an analytical standard for the "straight" chromium type of rustless steel, whereas the 0·3 per cent. Pb steel No. 212 is a Ledloy free-cutting steel, and is useful as an analytical standard for the determination of lead in steel. Where possible, the methods for Pb, S, and P recommended by the Iron and Steel Institute Sub-Committee on Standard Methods of Analysis have been used. Eight or nine different chemists representing independent analysts, Government Departments, manufacturers, and users of these grades of steel have taken part in the analytical standardisation.

The Measurement of Torsional Vibrations*

By R. STANSFIELD†

(*Continued from page 79, July 24th*)

Application of Filter for Separation of Frequencies

Frequency-selecting System.—The first application of the apparatus to a practical example of an engine in its development stage on the test bed, in contrast to earlier tests on fully developed engines, showed that suppression of surge and the introduction of a frequency-selecting unit would be invaluable additions.

A band-pass filter system was therefore constructed with a series of low-resistance chokes and an adjustable tuning capacity arranged as shown diagrammatically in Fig. 7. Typical calibration curves for one of the chokes are shown in Fig. 8. Curve A shows the relation between tuned frequency and capacity, and curve B shows the effect on calibration of the unit, the efficiency being different for each frequency. The percentage rejection of frequencies which varied 20 per cent. from the resonant setting was of the order of 80 per cent. for this choke over the intended working range.

Fig. 9 shows further records from the six-cylinder two-stroke engine taken with the

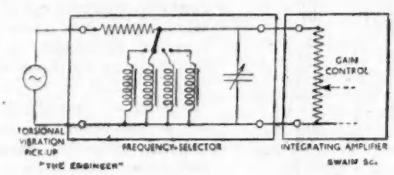


FIG. 7—*Band-pass Filter System*

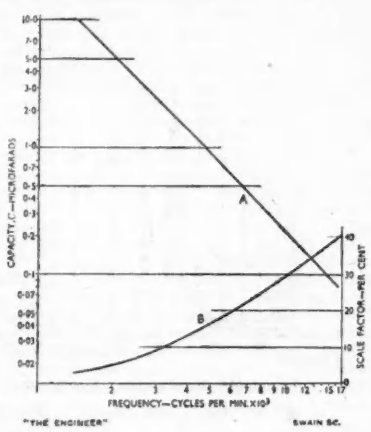
frequency selector set to the resonant frequency of the shaft, *i.e.*, 5800 vibrations per minute.

These correspond to the unfiltered diagrams of Fig. 5, and illustrate the value of the filter unit. The first diagram in each figure was taken just below the fifth-order critical speed; the second and third are on the upper flank of the major sixth order; the fourth is almost on the sixth order at resonance; the fifth is on the lower flank of the sixth order; and the last shows the seventh order at resonance. The unfiltered diagrams are in many cases too confused by beats with forced vibrations at other frequencies for accurate direct measurements of the critical amplitudes to be made; but the filtered records, which are quite steady on the screen, can be measured accurately, or traced if desired, and curves can be plotted for the entire speed range from these measurements. The height of such a curve at any given speed represents the amplitude of the harmonic at the frequency of the system to which the frequency selector has been tuned.

Fig. 10 is a graph of this type taken from a six-cylinder four-stroke diesel engine driving a generator through a Bibby coupling. The engine had a friction damper at the free end of the shaft. Starting with the unfiltered diagram, the engine was run through the speed range, and the speeds at which marked vibrations occurred were noted, the number of vibrations per cycle being counted to determine each order number. Two definite vibration frequencies were noted, the first occurring only at engine speeds below about 900 r.p.m., and the second above about 1050 r.p.m. The filter was then inserted and tuned to the approximate frequency for the lower speed range, 7550 vibrations per minute. The engine was then run from 580 r.p.m. upwards, the height of diagram being measured at intervals of about 20 r.p.m., and the number of vibrations per cycle was noted at each peak value indicating the order of the vibration. The lower resonant frequency is that of the system when the inertia mass of the friction damper is running solidly with the damper hub. Near 920 r.p.m. the shaft swings start to build towards the 7½-order critical vibration, but the damper then begins to "stick-slip," raising the natural frequency of the shaft system. The same order again tries to build up at a higher speed, and the damper movement then becomes stabilised with increase of frequency to 10,400 vibrations per minute. At higher speeds the ninth, 7½, and sixth orders are reached. A few points taken on full load show the difference between loaded and light running, and the sloping line from 1600 r.p.m. to 1660 r.p.m. indicates the governed speed of the engine.

In this example the fly-wheel mass was normal and the measured swings are a close approximation to those causing shaft stresses. The diagrams show the sum of all vibrations taking place at the frequency to which the filter is set. Thus in cases where the fly-wheel is small and the speed low, it is necessary to calculate the magnitude of the harmonic of the roll at this frequency and to adjust the observed swings to allow for this. This applies particularly to the values for the numerically low major orders.

An explanation is necessary regarding the interpretation of the flanks of the curves of



Curve A: Capacity, microfarads (μf).
Curve B: Scale factor.

FIG. 8—*Calibration Curves for Filter Unit*

graphs similar to Fig. 10. The flank of the sixth-order critical vibration on this graph does not represent the amplitude of the sixth harmonic forced vibration at each speed below resonance, but that of the harmonic for 10,400 vibrations per minute to which the filter was tuned. If, however, the filter is re-tuned, at any speed in a trough between two peaks, to six times engine speed, then, provided that the resulting wave shows twelve definite cycles, the height of the waves gives the amplitude of the flank of the sixth order at that speed, plus the harmonic at the tuned frequency of any roll, which is usually negligible.

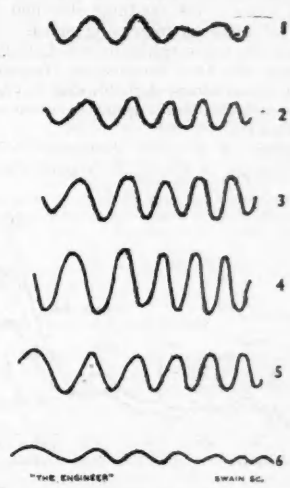
Summarising, the use of the frequency selector enables diagrams to be taken from which all major, and even relatively insignificant minor, critical vibrations can be measured. It can also be used for the determination of flank amplitudes when the forced frequency is not below about 1000 vibrations per minute. The harmonic of the roll at any selected frequency is included, and is, of course, embodied in any other type of torsiogram, except those derived from torsional strain gauges. Errors due to direct measurement of the diagrams are in the direction of excess swings, and are thus on the safe side.

Summary of Operating Technique.—The best operating technique for a full analysis of an engine is described in the following subsections, numbered (1) to (11):—

(1) *Study of Unfiltered Diagrams.*—Run through the speed range on a steady load, using the unfiltered diagram, and note the speeds at which pronounced resonance occurs. Watch particularly for vibrations of different degrees. If possible, make this search with the designer's analysis of the system at hand for reference. At resonant speeds count the total number of vibrations to determine the order, and then calculate the approximate natural frequency for each mode of vibration by multiplying the number of vibrations per revolution by the engine speed.

(2) *Choice of Filter Setting.*—Set the filter to one of the approximately determined natural frequencies, adjusting the amplifier to obtain a suitable scale for the filtered diagram, and then measure the height of the filtered diagram at a resonant speed. Make a small adjustment of the filter setting to each side of the initial setting, and, if there is any increase of amplitude with such an adjustment, check the speed again for a new maximum, and in this way obtain the optimum combination of filter setting and speed which gives the maximum height of diagram for the order under examination. The filter setting should then be left at this setting and the calibration determined from the appropriate calibration curve for the choke and condenser values in use, and the switching position of the amplifier.

(3) *Complete Record of Speed Range.*—Now run the engine through the whole of the speed range over which readings are required, taking measurements of diagram height every 20 r.p.m. or other convenient speed gap, and repeat this procedure at full load. A similar series of readings should then be taken with the filter



Scale, 4·3 cm. per deg. throughout.

Diagram	1,	1133 r.p.m.
,,	2,	1040 r.p.m.
,,	3,	1020 r.p.m.
,,	4,	1000 r.p.m.
,,	5,	910 r.p.m.
,,	6,	835 r.p.m.

FIG. 9—*Filtered Diagrams Corresponding to Fig. 5*

set to the frequency of any other mode of vibration which was observed during the preliminary tests with the unfiltered diagrams. Note that the resonant frequency may change with load.

(4) *Amplitudes at Each Point of Resonance.*—These records enable curves, such as those of Fig. 10, to be plotted. The peak heights represent the amplitudes of the vibrations at each point of resonance. The values of the various orders can usually be determined by a direct count of the number of waves per revolution seen on the screen. In the case of orders with low vector summations, however, there may be some doubt regarding the exact order on account of interference with other frequencies. The order number can in such cases readily be determined by inspection of the finished graph, and it can then be checked from the known constants for the engine system under test. If a continuous film camera is available, it is worth taking a photographic record over the speed range at, say, no load and full load, to which reference can be made later for complete analysis and check if desired.

(5) *Flank Results.*—Next, after inspection of the plotted results, decide whether the heights of the flanks of any order are required, bearing in mind that critical vibrations beyond the maximum speed may have large flank ampli-

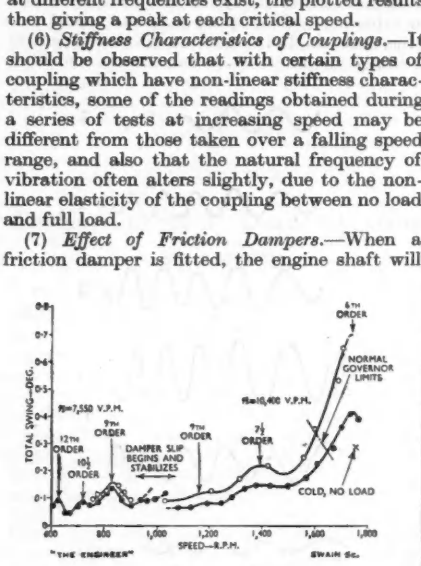
* Institution of Mechanical Engineers, July 17th, 1942.—Abstract.

† Chief Research Engineer (Sunbury Laboratories), Anglo-Iranian Oil Company, Ltd.

tudes. To determine flank values for a given order, set the filter to a frequency equal to the number of the order, multiplied by a speed corresponding to a trough between two resonant speeds, and take a reading with the engine running at this speed. Repeat this procedure with the filter set to a frequency equal to the number of the order multiplied by a speed corresponding to the next trough, and continue this process as far as required. If the peak of an important order is sufficiently below the maximum speed of the engine, make similar tests at higher speeds than the resonant one. The line joining these values and merging into the peak values gives the shape of the vibration curve for the order examined, and enables flank values to be added to resonance effects at other order numbers, and to other important flank effects determined in a similar manner. No account is taken of phase change between the various orders, nor of the fact that the stress per degree swing due to forced vibrations is not the same at the node as it is for the critical vibrations, but the error due to neglect of these is on the safe side. The "flank method" also shows when two important modes of vibration at different frequencies exist, the plotted results then giving a peak at each critical speed.

(6) *Stiffness Characteristics of Couplings.*—It should be observed that with certain types of coupling which have non-linear stiffness characteristics, some of the readings obtained during a series of tests at increasing speed may be different from those taken over a falling speed range, and also that the natural frequency of vibration often alters slightly, due to the non-linear elasticity of the coupling between no load and full load.

(7) *Effect of Friction Dampers.*—When a friction damper is fitted, the engine shaft will



The curves show the total amplitudes of the harmonics at 7550 and 10,400 vibrations per minute for a six-cylinder diesel engine direct-coupled to a generator through a Bibby coupling. Firing order: 1, 5, 3, 6, 2, 4.

● No load.

○ Torque for 50 kW at 1500 r.p.m.

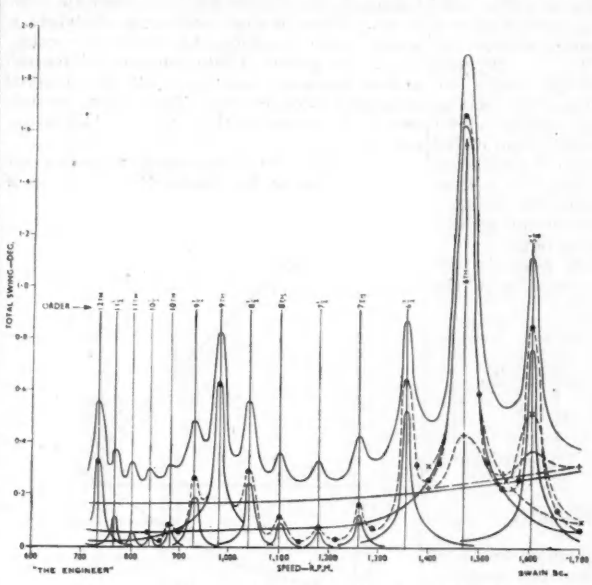
FIG. 10—*Harmonic Analysis of Diesel Engine Vibrations*

have a natural frequency which is determined by considering the damper mass as though it were fixed to the hub when the amplitudes of vibration are below a certain limit, but when the damper slips appreciably the natural frequency of the shaft will rise to an extent depending upon the design of damper and the loading of its springs. In such cases every important order should be explored from the peak in both directions for flank effects, *i.e.*, the filter system should be tuned to the order number multiplied by the engine speed for a range of speeds, particularly for those above the critical speed applying to the damper in the "frozen" condition. In many examples this search will show the existence of two peaks, each for the same order, the lower-frequency peak corresponding to the critical with the damper mass frozen and the higher-frequency peak corresponding to the same critical when the damper is slipping at its maximum freedom.

The nature of the friction surfaces and the loading determines which of the two peaks is the greater or whether they merge in a smooth curve with broad flank effects. It is also possible to have examples in which the damper acts as a fixed mass at low engine speeds and as a light friction brake at higher speeds, the natural frequencies being different and not merging into each other around each critical speed.

(8) *Effect of Friction Clutches.*—When an engine system includes a friction clutch or gear drive, which can be disengaged at no load, tests should be made in the neutral or disengaged position, as such drives may act as powerful dampers if they are suitably situated, and they may, of course, be subjected to unexpected loads or duty in consequence. The importance of testing engines complete with the driven system arranged to reproduce as nearly as possible the final service conditions cannot be overestimated.

(9) *Filter Discrimination.*—The effect of incomplete rejection of frequencies other than that to which the filter is tuned is shown in Fig. 11. The series of full-line curves gives the calculated harmonic swings for each order



Six-cylinder diesel engine. Firing order: 1, 3, 5, 6, 4, 2.

– – –●– – – Values with filter set to 8820 vibrations per minute.

– – –×– – – ,, ,, 6×speed.

– – –+– – – ,, ,, 3×speed.

FIG. 11—*Relation between Experimental Curve and Separate Harmonic Component Swing*

from 12 to 5½ for a six-cylinder engine with firing order 1, 3, 5, 6, 4, 2, the example having been chosen to bring a large minor order immediately at each side of a major order, and so to illustrate the maximum effects of filter imperfections. The upper full-line curve is the arithmetic summation of the various orders, and therefore represents total vibratory swing, neglecting phase effects.

(10) *Construction of Curves.*—From knowledge of the filter characteristics‖ it is possible to construct a curve showing the values which would be obtained experimentally from the series of components shown. This is given by the dotted line marked with small circles, the filter being tuned to 8820 vibrations per minute, the natural frequency of the system. It will be seen that the major orders are very little exaggerated, and that the troughs are raised, due to imperfect filtering of other frequencies than 8820 per minute. Errors are on the safe side. No account need be taken of the fact that a filter circuit does not reproduce the ratio of the maximum and minimum amplitudes of an unfiltered vibration quite accurately if the vibrations have a high decrement, as such cases do not occur at any important point in engine practice.

(11) *Influence of Flank Values.*—The diagram determined with a constant filter tuning is sufficiently accurate to be taken as the true flank where its slope is large, but as the flank flattens and becomes small compared with swings at other frequencies, it is desirable, as stated previously, to determine flank values only at speeds corresponding to troughs between two resonant speeds. The dotted line marked with vertical crosses from 1400 r.p.m. to 1700 r.p.m. shows flank determinations for the third order, and it will be seen that these are only reliable where they are taken under troughs. The dotted line with the diagonal crosses between the same speeds shows the sixth-order flanks.

Damping Factors.—In many practical examples it will be found that much less marked peaks are obtained than in the theoretical case of Fig. 11. This is because the natural frequency of an engine system is rarely a precise value, but is a variable over a range depending upon any detuning member which may be present. Friction dampers, the damping due to generators, spring couplings, rubber couplings, and even connecting-rod obliquity effects, all have some detuning influence resulting in reduction of peak heights and an increase in the width of resonance curves.

Attention has already been drawn to the fact that experimental errors when using the recommended technique for the filter are on the safe side. When a direct addition of amplitudes of a low-order minor critical vibration and, say, two lower-order flanks is made, it may be found that the total estimated stress exceeds the permissible range. In such cases a closer check is desirable, using the test data for determining natural frequencies and amplitudes at resonance, and calculating the curves for each harmonic order in terms of these frequencies and the damping factor necessary to give the recorded amplitudes.

First-order waves must be taken with caution, because a small spurious effect may be introduced, due to rotation of the pick-up in the earth's field, although this could be eliminated by screening.

‖ A subsequent filter designed by Standard Telephones and Cables, Ltd., has better characteristics than that used for the tests reported, giving a closer approach to the true harmonic curves. A theoretically perfect filter is undesirable, being difficult to handle in practice, and without appreciable compensating advantages for normal testing.

New Mississippi River Bridge

THE latest of several modern bridges over the Mississippi River, U.S.A., is a highway bridge from Chester, Illinois, to the Missouri bank. In a total length of 2826ft., its main feature is a continuous through truss of 1340ft., forming two spans of 670ft. over the main channel. At each end is a continuous deck truss of 500ft., while the approaches are plate girder spans of 60ft. The headway or clearance is 107ft. at low water for the main spans. Erection of the 1340ft. trusses, which are 30ft. apart, was begun at the centre pier, the material being handled by a derrick barge or floating crane. For the span on the Illinois side three temporary piers were used, but on the Missouri side only one such pier was provided, requiring a cantilever length of 400ft. As soon as the truss work on the central pier was completed, two derricks were mounted on it and started cantilever construction in both directions, the supported Illinois span serving as the anchor arm for the longer cantilevering of the Missouri span. The bridge will have a 20ft. two-lane roadway, with two 6ft. walks carried on cantilevered floor beams, outside of the trusses.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

Scheme to Encourage Wolfram Production

To encourage the production of wolfram by individuals and small groups of workers, the Ministry of Supply are prepared to arrange to purchase small quantities of rough concentrates of an assay value down to 10 per cent. WO_3, on the basis of a price of 100s. per unit of WO_3 as 65 per cent. clean concentrates, less the charges set out below, and less an allowance for low-grade material. Arrangements have been made for the concentrates to be purchased by Non-ferrous Minerals Development, Ltd., at Plympton, on behalf of the Ministry of Supply, who are the sole authorised buyers. Parcels of concentrates should be sent carriage paid to Plympton (G.W.R.) Station, addressed to Non-ferrous Minerals Development, Ltd., Plympton, Plymouth, who should be advised by letter. Parcels will be weighed, crushed and sampled and the producer can be present, or represented, if he wishes. Assays of samples will be made on behalf of the Ministry and while they must be accepted as final, every care will be taken to ensure that the appropriate value is placed on the parcels by the company acting for the Ministry. Charges and payments will be as follows:—(1) For collection, weighing, sampling and dressing a charge at the rate of 1s. per cwt. (112 lb.) of rough concentrates will be made, with a minimum of 5s. for small parcels under ¼ ton in weight; (2) there will be a uniform charge of 15s. per parcel for assaying; (3) magnetic separation will be charged at the rate of 1s. per unit of tin metal and per unit WO_3 paid for; (4) payments will be made on the basis of recoverable tin metal and WO_3. In the case of simple ores, if the rough concentrates contain less than 20 per cent. of tin plus WO_3, 90 per cent. of values will be paid for; between 20 per cent. and 30 per cent. of tin plus WO_3, 92 per cent. of values will be paid for; between 30 per cent. and 40 per cent. of tin plus WO_3, 94 per cent. of values will be paid for; between 40 per cent. and 50 per cent. of tin plus WO_3, 96 per cent. of values will be paid for; above 50 per cent. tin plus WO_3, 98 per cent. of values will be paid for; above 65 per cent. tin plus WO_3, 100 per cent. of values will be paid for. Any complex ores and concentrates offered will be accepted only after recovery tests have been made; (5) tin metal will be paid for at a price per unit of 22·4 lb. based on current metal prices; WO_3 will be paid for at 100s. per unit of 22·4 lb.; both less 1s. per unit (as above) for the cost of magnetic separation; (6) settlement will be made as to 75 per cent. on estimated value of parcels when received, balance after receipt of assays.

The Pig Iron Market

The volume of business in the pig iron department has decreased during the last fortnight or so, although the production is fully maintained. Outputs are passing almost immediately into consumption, but the uncertainties of the position have resulted in many firms showing a tendency to hold off the market and rely to some extent upon their stocks. The increase in the price of fuel and the uncertainty as to whether there will be any advance in the price of pig iron has been a disturbing influence in the trade, and the concentration scheme until foundries obtain some knowledge of how they will be affected by it will have an adverse effect. There are thus good reasons why the authorities should act promptly and relieve the trade from the uncertainties which are disturbing it. A large number of licences have been issued to buyers and in some cases the latter have issued specifications for material which will be needed before the end of July, but a large number appear to be holding back their orders until the situation is clear. There are liberal supplies of high-phosphoric pig iron and buyers therefore are perhaps more inclined to hold up orders for this description than for the grades which are less plentiful. The tightness in the hematite position persists and this probably will become accentuated before it is easier. Licences for hematite are now only issued when the iron is required for special purposes. The extensive use of low-phosphoric pig iron and refined pig iron as substitutes for hematite has caused some stringency in these descriptions, and for this reason outputs pass quickly into consumption. So long as the engineering foundries are heavily engaged in producing castings for munitions and armaments their pig iron requirements will be on a heavy scale; but, despite this, there have been no reports of any firms having been held up by difficulties in obtaining the quantities of pig iron they require.

The Midlands and South Wales

Although this is the mid-holiday season, outputs at the Midlands steel works are maintained at a high level, chiefly because the holidays have been organised to that end, so that there is no general shut-down of all works in a district, such as used to occur in peacetime. The pressure to obtain supplies is unrelaxed and in some of the departments works are hard put to it to keep their delivery dates. Recently there has been a slightly better demand for heavy structural steel. This has been the case for several months, and it is doubtful if the present slight revival will be permanent, since the constructional engineers have comparatively few jobs in sight requiring large tonnages of this material. There is, however, a steady demand for the lighter sizes of structural sections. Both steel works and the re-rollers report that the demand in this department is likely to keep them busy for a long time. The plate mills are fully employed and are likely to remain so for an indefinite period, since large tonnages are being used by the shipbuilders, tank makers, wagon builders and heavy engineers. An active business is also passing in the heavy gauges of sheets, but the demand for sheets of lighter gauges is not more than moderate and the volume of business coming forward shows a tendency to slacken. Consumers, however, appear to have become accustomed to using black sheets in lieu of galvanised, which are only permitted to be made by special authorisation. The armaments and munitions makers continue to take considerable quantities of special steel and there is no sign of their requirements diminishing. The steel works in South Wales are fully employed and the demand shows a tendency to increase. As in other parts of the country, the plate mills are engaged for some time ahead and the production is on a satisfactory scale. Increased pressure by consumers is noticeable in semi-finished steel and the demand for steel billets is steadily growing and some producers are finding it difficult to keep abreast of their deliveries. There is a steady but only moderate demand for sheet and tinplate bars, but it is sufficient to absorb the quantities of steel allocated to the consumers. Business in tinplates is quiet and the demand for substitutes, which have to be accepted by consumers as a result of Government restrictions on the use and manufacture of tinplates, is on the quiet side. A fair business is passing in black and painted sheets, whilst recently there has been an increased request for black corrugated sheets.

The North-East Coast and Yorkshire

It is evident that the resources of the steel works on the North-East Coast will be fully taxed to complete the orders they have in hand for delivery by the end of September. Practically all departments are in the same position. Rather stringent conditions have developed in the semi-finished steel department, and it is understood that increased quantities of semis will be imported from the United States, since the stocks of imported material in this country have been drawn on to a considerable extent. The demand for semis is as heavy as at any time during the war, and so long as the present demand from armaments and munitions makers continues the drain upon this class of material will continue. Re-rollers are taking large quantities and in many cases are pressing for additional supplies. There is not much opportunity now for consumers to build up stocks of semis, as they were able to do about this time last year. No special features have developed in the steel trade, and the most active item remains the big business passing in plates and the call for special and alloy steel. All the plate mills are occupied to capacity and there is a tendency for delivery dates to lengthen in spite of efforts which are being made by the authorities by transferring orders and by introducing a method of standardisation of sizes to ease the position. Armaments and munitions makers are the principal users of special steel and the whole production of this is immediately taken up by consumers. Quiet conditions prevail in the heavy structural steel department, although there is a continued active demand for the lighter sizes. The call for steel bars also is insistent and the engineering industry continues to absorb large tonnages of bars of 3in. and up. The Yorkshire steel works have sufficient orders on their books to keep them fully employed until the end of Period III and are not anxious to book fresh business. In spite of the huge demand, however, the steel makers continue to meet their obligations and few complaints are heard of late delivery. Production of special steel and stainless steel is at a high rate, but is barely sufficient to meet the demand, which appears to be increasing. The works producing plates, also, are subject to severe pressure from consumers. Large tonnages of plates are being produced, including armour plate. The production of acid carbon steel is at a high level, whilst all the basic steel works are operating at capacity.

Scotland and the North

With the Scottish iron and steel works employed almost entirely upon war work there is practically no capacity available to meet civilian requirements or export business which might mature even were the shipping position more favourable to this trade. The insistent demand for plates remains a feature of the position and large tonnages are passing to the shipyards, where a big programme of work is in hand. Ship, boiler and tank plates are in equal request, but there are indications that the demand for boiler plates will decline, since the boilermakers are understood to have experienced a decline in the amount of work coming forward. Business in special and alloy steel is unchecked and all the works producing this class of steel are operating at capacity. There is also a huge demand for shell steel. In some departments the volume of new business has been influenced by the holidays at many of the consuming works. The production of semis is maintained at a high level, but so heavy is the demand that the output of the Scottish works has to be supplemented with imported material. The re-rollers, however, have little cause to complain of their raw materials position, so far as billets are concerned, and they are turning out big tonnages of small bars and lighter sections, whilst they are experiencing an active and steady demand for strip. Good tonnages of reinforcing rods and fencing bars are being taken up. The tube works are fully employed and there is an active demand for rivet, nut and bolt iron. In the Lancashire iron and steel market the demand for alloy steel is maintained, and makers are well booked up for some time to come. There is an active inquiry in circulation for considerable quantities of stainless and acid-resisting steels. There is a big local demand for semi-finished materials of both acid and basic sorts. The Lancashire ironworks have a moderate tonnage of orders in hand and are receiving a fair amount of new orders. Most of the business transacted is in Crown quality bars, but for other kinds the demand is on the quiet side.

Copper, Tin, Lead, and Spelter

The general situation regarding supplies of non-ferrous metals in Great Britain is satisfactory. The Control has to conserve supplies and is rigorously restricting the use of metals to purposes associated with the national effort. This results in an increasing restriction of supplies of metals for civilian requirements and is a process which is in force in the United States as well as in this country. So far as copper is concerned the position appears to be satisfactory and supplies continue to reach this country in sufficient volume to meet the requirements of the war industries. These are employed at full stretch and large tonnages of copper are going to the brass makers, whilst other industries engaged in producing for the war effort are also taking up considerable quantities. In the United States production is being pressed to the utmost and large quantities of copper have been obtained from Chile and other South American countries. There is a huge war demand in the United States and little copper is made available for civilian purposes. . . . Great efforts to restrict the use of tin to only the most important war purposes are having their effect in reducing consumption, whilst strenuous efforts are being made at the same time by the United Nations to increase production in the countries under their control. It is understood that fresh attempts to bring Cornish mines into production are being made and that Canadian miners are being employed. It is believed that the steps which have been taken in Great Britain and the United States to restrict the use of tin will assure the United Nations of adequate supplies during the war. The Japanese claim that the tin smelter at Singapore is again in operation, but the statement is regarded with suspicion. . . . No fresh developments have occurred in the lead situation of late. The use of the metal in Great Britain and the United States is restricted, but although the position is regarded as somewhat stringent, the firms engaged upon war work are receiving the metal they require. In that country a proposal has been made that the Metal Reserve Company should build up a strategic reserve of 200,000 tons. . . . There is a big demand for spelter of both high grade and G.O.B. sorts, but the war industries have been supplied with their full requirements. The Control, however, is taking great pains to limit the use of the metal to essential purposes. In the United States the consumption is also on a heavy scale and the position appears to be somewhat tight, although it has improved during the past few weeks.

Notes and Memoranda

Rail and Road

L.M.S. RAG SALVAGE.—Four hundred and fifty tons of rope, string, sacking and rags have been salved by the L.M.S. Railway during the last three months. This includes torn and unusable coal bags, which, before the war, were regarded as useless. They now go to papermaking.

ELECTRIC RAILWAYS IN CALIFORNIA.—The California Railroad Commission is seeking Federal funds to finance immediate extension of seven electric railway lines near Los Angeles, in order to improve service to seven aircraft factories and provide harbour facilities in the area. These industries at present can be reached only by motor transport.

A RECORD FREIGHT.—An American railway—the Charleston and Western Carolina Company—claims to have hauled recently one of the longest and perhaps the heaviest freight train yet demanded by war conditions. It consisted of 102 loaded cars, sixty-five of which carried coal from the Clinchfield mines. The total load was not far short of 8000 short tons. The distance from the mines to Augusta, Georgia, is 87 miles, the track being a single one.

AMERICAN ROLLING STOCK CONVERSION.—The Chicago and North-Western Railroad has recently converted eleven parlour type and lounge cars into passenger coaches as the first step in the conversion of luxury equipment to meet war conditions. The establishment of war production plants in new areas and the transport of workers to and from those plants has made new demands on passenger stock. By converting luxury coaches the carrying capacity of existing passenger equipment can be increased.

L.N.E.R. USE OF BRIQUETTES.—Economy in the use of locomotive coal is being made on the L.N.E. Railway by the use of fuel briquettes composed of coal dust, sawdust, and tar or petroleum residuum as a binding agent. The briquettes measure 10in. by 6¼in. by 4¾in., and are thus slightly larger than a household brick. After being baked they weigh 13½ lb. each. They are mixed with supplies of ordinary steam coal, approximately in the proportion of 25 per cent. briquette and 75 per cent. coal. *The Railway Gazette* states that the briquettes are being used experimentally on engines hauling freight trains and local passenger trains, and so far they have proved satisfactory. No difficulty has been experienced in maintaining steam pressure.

Air and Water

CANADIAN DESTROYER.—H.M.C.S. "Huron," one of a number of "Tribal" class destroyers, building for the Royal Canadian Navy, has recently been launched.

A VETERAN DESTROYER.—The oldest destroyer in the British Navy, H.M.S. "Skate," has recently celebrated her silver jubilee afloat. She is of the old "Admiralty R" class and was built in 1917 by John Brown and Co., Ltd., Clydebank.

AMERICAN SHIPS FOR EIRE.—The United States Senate has adopted a resolution authorising the Maritime Commission to sell or charter two merchant vessels to the Government of Eire for the transport of food supplies from the United States to Eire.

U.S. MARINE ENGINE WORKS.—An expansion of facilities at the Joshua Hendy Ironworks, Sunnyvale, California, for the production of additional reciprocating engines, has been authorised by the U.S. Maritime Commission. At present the works are under contract to produce ten engines per month, and it is expected that the increase will step up the rate to nineteen engines per month.

AERO-ENGINE RESEARCH LABORATORY.—It is reported by *The Aeroplane* that a new aero-engine research laboratory for the National Advisory Committee for Aeronautics is now at work at Cleveland, U.S.A. The first units of the laboratory are operating one year ahead of schedule. The laboratory includes a wind tunnel for testing motors of up to 4000 H.P., a test stand for airscrews of 22ft. in diameter, a fuel and lubricants test building, a flight research hangar, and an ice tunnel.

SWEDISH TRAINING SHIP.—The launch recently took place, from the Lindholmen Yard, Gothenburg, of a four-masted fore-and-aft motor schooner, "Albatross." She is about 1400 tons deadweight and, according to *Shipbuilding and Shipping Record*, has been ordered by the Brostrom concern to be used by its companies as a training ship for future deck and engine-room officers. The ship, which is built for ocean navigation to the highest class of Lloyd's Register with ice strengthening, has a length of 200ft. and the speed by motor will be about 9 knots with full cargo. The propelling machinery consists of an eight-cylinder diesel engine of Eriksberg make, driving a rustproof propeller with two hydraulically reversible blades.

SHIPYARDS AND SCRAP METAL.—A Ministry of Works inspection of shipyards in the North-East of England has revealed that nearly 200 extra tons of scrap metal per week are now being recovered from twenty-five shipyards, compared with the amounts collected four months ago. The shipyards of Tyneside and Tees alone are saving the nation an extra 10,000 tons of iron a year. This has been achieved by the co-operation of all concerned, and many of the shipyards have appointed special recovery officers and squads whose job it is to find the scrap and keep it moving in a steady regular flow to the furnaces. Most of the scrap comes from repair and conversion work—old plates, old boilers, bars, machinery and gear, as well as many tons of smaller stuff, such as cuttings, punchings, and broken rivets.

Miscellanea

ALCOHOL FROM WHEAT.—The production of industrial alcohol from wheat is being started in Australia, and a distillery has recently been opened in the heart of the wheat-growing country. Four distilleries are being built, each capable of producing three million gallons of industrial alcohol.

THE LATE MR. B. J. HUGO.—We regret to learn of the recent death at the age of sixty-two of Mr. B. J. Hugo. He was well known in production engineering circles in both London and the Midlands, and was a founder member of the Institution of Production Engineers. During recent years he was connected with the machine tool trade in the Midland area.

FUEL ECONOMY TRAINING SCHEME.—The Minister of Fuel, in a recent parliamentary answer, has stated that in the industrial sphere advisory committees are being set up in all regions, with panels of combustion experts, and a training scheme has been started, with the collaboration of the Board of Education, at some forty-five universities and colleges. Over 4000 men have received training under the initial plan, and it is likely that over 10,000 will be trained as the scheme develops.

THE LATE MR. J. A. COLOMBI.—We regret to learn of the death, on July 26th, in London, of Mr. J. A. Colombi, chief outside engineer to the Brush Electrical Engineering Company, Ltd., Loughborough. Mr. Colombi was associated with the company from 1902, and served his pupilage at the Falcon Works. After completing his training he was employed for some years on the testing staff. Later he went to India to join the Bombay Electric Tramways Company, and returned to this country in 1921 to rejoin the Brush Company as outside engineer.

BALL AND ROLLER BEARINGS.—To secure the most equitable distribution for production usage of ball and roller bearings and to prevent over-stocking of such bearings, the Ministry of Supply has issued an Order which came into force on July 22nd, controlling the acquisition and stocking of bearings. Production usage of bearings means those instances where bearings are used in the production of any other article, and whether obtained direct from bearing manufacturers or through second parties. This Order does not affect bearings required for repair or maintenance of any other article.

THE SINTERING OF SILVER.—The shortage of tin and some other metals has turned the attention of metallurgists to silver as a metal for some alloys for special purposes. Graphite, tantalum, molybdenum, and tungsten are among the materials which can be mixed in finely powdered form with silver powder and then compressed and sintered. The products of these processes can be rolled into sheet or drawn into rod for making electrical contacts and welding electrodes, and other applications are being examined. Wire suitable for heading operations can be produced, since silver itself is ductile and helps to form ductile mixtures.

Personal and Business

LIEUT.-COLONEL N. H. OAKLEY-EVANS, M.C., managing director of Armco, Ltd., has resigned from the boards of Armco, Ltd., British Bundy Tubing Company, Ltd., and Engineering and Metals Company, Ltd., and is no longer responsible for the management in Great Britain of the affairs of the American Rolling Mills, Middletown, Ohio.

MR. WILLIAM LEON has been elected chairman, and Sir W. Reardon-Smith vice-chairman, of Mountstuart Dry Docks, Ltd.

THE PLASTICS CONTROL of the Ministry of Supply has moved to Universal House, 56, Buckingham Palace Road, S.W.1. Telephone, Sloane 9985.

SIR HENRY TIZARD, Rector of the Imperial College of Science and Technology, has been elected President of Magdalen College, Oxford, in succession to the late Dr. G. S. Gordon.

MR. R. PENDENNIS WALLIS, Ph.D., M.Sc., Wh.Ex., &c. (late of E. Green and Son, Ltd., Wakefield), has joined the board of directors of Bennis Combustion, Ltd., Little Hulton, Bolton.

British Standards Institution

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

TEST CODE FOR COKE OVENS

No. 999. This code forms one of a series which is being prepared. It applies to by-product coke ovens, and contains all the necessary data for the determination of the performance of the plant and the yields and qualities of the saleable products, together with a full explanation of how the necessary observations should be made. Purely scientific data not considered to be of importance to the operation of the plant are omitted. Price 3s. 9d. post free.

SILICON BRONZE INGOTS AND CASTINGS

Nos. 1029–1030. This publication is a further contribution to the action that is being taken to effect economy in the use of tin by substituting gun-metals and other tin-bearing alloys with alloys which do not contain tin. The specification follows the lines of the other British Standards in the series for copper alloy ingots and castings. It is hoped that it will be possible for this alloy to be used in appropriate instances for gun-metal and other rich tin alloys for special castings, provided the founders have had experience with the working of this alloy.

BLAST-FURNACE SLAG

No. 1047. Owing to the difficulties at the present time of securing the necessary output from the quarries, this specification has been prepared to enable blast-furnace slag to be used as an alternative. The specification has been based on the results of work carried out by the Building Research Station on the use of slag as a graded aggregate. The chemical tests which are necessary to determine that the aggregate is suitable are set out in full in the specification. The properties specified for the aggregate include the crushing strength, the weight per cubic foot, the stability, the chemical composition, the water absorption and the grading (sieve analysis). The specification also contains as an appendix general notes on the properties of concrete made with blast-furnace slag aggregate.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Architects, Surveyors and Technical Assistants

Tuesday, Aug. 4th.—WESTMINSTER BRANCH: Livingstone Hall, Westminster, S.W.1. Discussion, "Wartime Building in the U.S.S.R.," opened by D. Percival. 6.30 p.m.

Institution of Automobile Engineers

Wednesday, Aug. 19th.—LUTON CENTRE: George Hotel, Luton. General meeting. 6.30 p.m.

Printing.—George Reveirs, Ltd., 10-12, Rosebery Avenue, E.C.1, are PREPARED to SUBMIT ESTIMATES for all DESCRIPTIONS of PRINTING. "THE ENGINEER" has been printed at this establishment from its commencement.

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At Thornycrofts, skilled instructors ensure that women recruits and workers promoted to other machines reach production standard in record time

"I'll never forget my first day at Thornycrofts! Guided by the Supervisor I had decided to be a machinist—but my first view of a machine shop, with its bewildering bustle and mass of machines, made me wish I had chosen otherwise. Nevertheless, one soon gets accustomed to this, and under the expert tuition of the foremen, with skilled men and women on similar jobs ready to advise, it is surprising how quickly one becomes adept—and fascinated by the work. Why, some of our women are even screw-cutting, now!

"But more and more women are wanted everywhere—to replace the men called-up and to provide the equipment they'll need—and there is no better way of helping the war effort, whilst earning good wages, too! So, if your women folk are ineligible for the Services, induce them to go into the works—the local Employment Exchange has particulars of the full-time and part-time jobs available."

★

A call for women for war work by

THORNYCROFT

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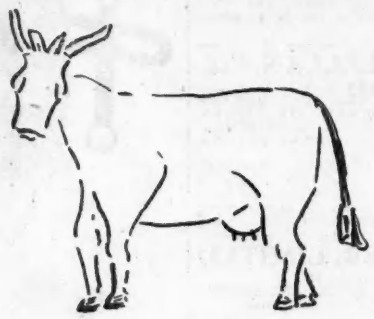

ONCE UPON A TIME

Cow used to make milk for our porridge, but really a NECO Motor did the work—Cow just stood by. Now there are so few NECO Motors available to drive milking machines Cow has to do something for herself and this makes her tired so there's not so much milk.

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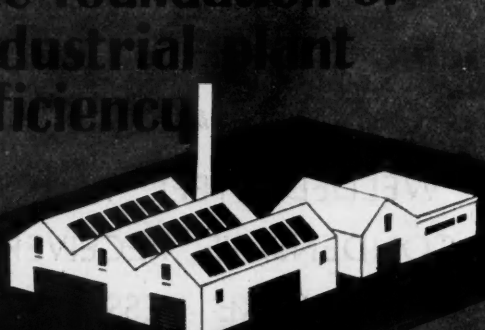

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